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PROCEEDINGS OF THE MATERIAL QUALITY TESTING RISK ASSESSMENT AND MULTI-STATE PEER EXCHANGE MEETING

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A report of the findings of
ICT-R27-62
Material Quality Testing Risk Assessment and Multi-State Peer Exchange

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16. Abstract

The primary objectives of this study were to compare the practices of the Illinois Department of Transportation (IDOT) with those of other state and federal agencies to share advice, best practices, and lessons learned, and to plan for the best possible Quality Control and Quality Assurance (QC / QA) and risk assessment procedures as IDOT moves forward in today's changing business climate. This report outlines the incentives behind this research project, documents relevant literature related to QC / QA, summarizes the discussions of the Peer Exchange, and provides recommendations for IDOT based on a synthesis of the foregoing research items.

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This publication is based on the results of ICT-R 27-62, **Material Quality Testing Risk Assessment and Multi-State Peer Exchange**. ICT-R 27-62 was conducted in cooperation with the Illinois Center for Transportation; the Illinois Department of Transportation, Division of Highways; and the U.S. Department of Transportation, Federal Highway Administration.

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Hal Wakefield, FHWA
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EXECUTIVE SUMMARY

The primary objectives of this study, ICT-R27-62, *Material Quality Testing, Risk Assessment, and Multi-State Peer Exchange* were to compare the practices of the Illinois Department of Transportation (IDOT) with those of other state and federal agencies to share advice, best practices, and lessons learned, and to plan for the best possible Quality Control and Quality Assurance (QC / QA) and risk assessment procedures as IDOT moves forward in today's changing business climate. This report outlines the incentives behind this research project, documents relevant literature related to QC / QA, summarizes the discussions of the Peer Exchange, and provides recommendations for IDOT based on a synthesis of the foregoing research items.

Quality Assurance (QA) is the planned and systematic actions necessary to provide confidence that a product or facility will perform satisfactorily in service. QA addresses the overall problem of obtaining the quality of a service, product, or facility in the most efficient, economical, and satisfactory manner possible through continued evaluation of the activities of planning, design, development of plans and specifications, advertising and awarding of contracts, construction, and maintenance, as well as the interplay of these activities. Quality Control (QC) includes those QA actions and considerations necessary to assess and adjust production and construction processes so as to control the level of quality in the end product. In summary, QA is a process to ensure that the quality of the finished product meets specifications and is acceptable to the QA owner. It is the responsibility of the highway agency and consists of QC, inspection (sampling and testing), and acceptance.

The work plan for this research consisted of three phases to help IDOT continue evolving to ensure that the highest level of quality measures are maintained going forward. The first phase consisted of gathering information through a review of IDOT testing and evaluation procedures, policies, and practices. Additionally, interviews with IDOT Central and District Laboratory units and the Bureaus of Bridges and Structures and Construction provided information on current testing and evaluation programs. Finally, research on the select practices of other states uncovered the most appropriate candidates for a Multi-State Peer Exchange and Materials Testing Workshop. In the second phase of the project, the researchers organized and conducted a Multi-State Peer Exchange and Materials Testing Workshop with representatives from Bureau of Materials and Physical Research (BMPR), the Federal Highway Administration (FHWA), and four State DOTs with practices that could potentially benefit IDOT. In the third phase, the research, interviews, and Peer Exchange Meeting discussions were summarized, synthesized, analyzed, and evaluated with an emphasis on their relevance to IDOT's ongoing acceptance efforts.

Because the transportation assets managed by IDOT represent a significant economic investment for the taxpayers and citizens of Illinois, and the deterioration of these assets poses a very real and dangerous risk, this Peer Exchange provided IDOT decision-makers with the opportunity to interact with DOT employees from around the nation to learn about their solutions and varied approaches to the challenges faced by the government agencies responsible for overseeing the transportation industry in the United States. To maintain full, regular, and safe service across Illinois, it is necessary to ensure that quality materials and workmanship are provided to each project undertaken by IDOT.

The following document details the results of this research effort and indicates the need for further investigation for a fuller understanding of the national implications of IDOT's processes. A series of recommendations are the outgrowth of the great efforts and valuable input from the IDOT BMPR, District Materials Engineers, FHWA, and private industry, a review of materials and methods acceptance practices throughout the nation, conversations and manufacturing site visits with IDOT, discussions with NHDOT, TXDOT, MODOT, INDOT, and

FHWA during the QA Peer Exchange, and presentations at the NTPEP annual and Illinois meetings.

To maintain high levels of service and consumer satisfaction, and to achieve federal benchmarks for acceptance, IDOT must heed the recommendations of the Code of Federal Regulations (CFR) and the FHWA Quality Assurance (QA) Procedures for Construction. To lengthen and maintain transportation infrastructure performance life, persistent reinvestment in the people, products, and procedures needed for a complete road program must be continually reviewed and discussed throughout the transportation industry. Furthermore, IDOT should adopt a Total Quality Management (TQM) mindset and approach to encourage continuous improvement within their organization. The cost of testing must be weighed and when it is determined that the risk of failure warrants testing IDOT must have the equipment (maintained, repaired) to attain results. Further, more detailed recommendations, including cross-training, consciousness-raising, stream-lining, and cost-cutting measures, are presented in the body of this report and briefly listed in the conclusion.

Photo of QA Peer Exchange Participants (Murphy, 2009).

TABLE OF CONTENTS

PREFACE

Quality Control (QC) and Quality Assurance (QA) affect many aspects of our lives and the functioning of our communities, from the food that we eat, the water we drink, and the cars that we drive to the schools that our family members attend. Historically, IDOT has recognized the need for a Total Quality Management (TQM) System, which "functions to ensure that the certification of materials is performed in an efficient manner, and that the materials put in place meet the specifications and result in roads and bridges that have no defects" (IDOT, 1996; see figure 1). This report endeavors to show how TQM can be continued and improved at IDOT, based on a review of current practices, the efforts of other state Departments of Transportation (DOTs), and the recommendations of experts in industry and academia.

It is the goal of this project to assist IDOT in avoiding some of the egregious errors in QC and QA processes that frequently make the headlines.

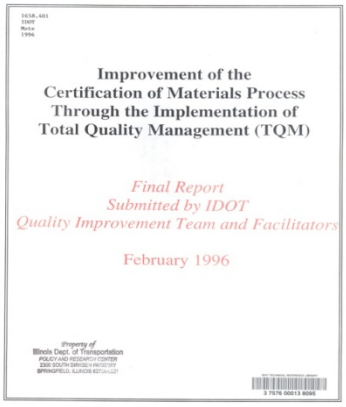


Figure 1. IDOT Final Report on TQM (1996).

To cite but a few international examples from construction, consumer safety, and travel security:

- In 1990, after widespread discoveries of substandard fasteners (nuts, bolts, and washers) in construction, defense systems, and aircraft, the Fastener Quality Act (Public Law 101-592), was signed into law by President George H.W. Bush to assure quality fastener product use (Earls, 2010).
- Since 2005, Boston's Central Artery and Third Harbor Tunnel Project (known colloquially as the "Big Dig") has been under investigation due to unexpectedly high costs, concerns about faulty construction, and safety issues. As of May 2010, various individuals involved in fraud, materials noncompliance, and otherwise endangering the safety of pedestrians and motorists are under investigation or house arrest (AP, 2010).
- In September 2008, approximately 53,000 infants in China became ill after drinking contaminated milk. An industrial chemical, melamine, used to artificially boost protein content in watered down milk, led to kidney stones and kidney failures in children under the age of 2. The widespread health crisis is indicative of a breakdown in supervision of the dairy industry by the product quality watchdog agency (Chang, 2008).
- In December 2008, Northwestern University's Kellogg School of Management inadvertently sent acceptance letters to 50 rejected applicants, apparently because of a computer error. The incident led to the disappointment of 50 applicants and a public apology, a telephone apology, and application refunds from the school (Black, 2008).

- In March 2009, investigations into a salmonella outbreak that sickened almost 700 people and killed at least nine showed that private inspectors contracted by Peanut Corp. of America had failed to report contamination and sanitary problems at processing facilities. This blatant conflict of interest caused by hiring private inspectors was cited by the House Energy and Commerce investigations subcommittee as a direct cause of the delivery of tainted food products to consumers. The incident led to the recall of over 3,490 products and to the consideration of legislation to improve penalties for noncompliance with audit standards nationally (Alonso-Zaldivar, 2009).
- In 2009, Southwest Airlines paid a fine of $7.5 million for continuing to fly airplanes after being notified that they had missed inspections for structural cracks. Later that year, Federal Aviation Administration (FAA) officials grounded 46 Southwest Airlines jets that had unapproved exhaust gate assembly hinge fittings. The maintenance company hired by Southwest used parts provided by an uncertified subcontractor, thereby causing a potential safety hazard, canceled flights, and travel delays. As a result, Southwest's stock prices fell, and the airlines may face further penalties from the FAA (Koenig, 2009).
- In September 2009, Toyota was forced to recall millions of cars due to an oversight in the design of a floor mat near the gas pedal, which is alleged to have caused at least 16 deaths and 243 injuries (Saporito, 2010). In response to this tragic loss of life, the company suffered diminished public trust and market share value.
- In January 2010, CertainTeed Corporation settled a roofing shingle products liability litigation case with preliminarily court approval. The Plaintiffs alleged that organic asphalt shingles manufactured by CertainTeed from July 1, 1987 through 2005 are subject to premature failure and otherwise do not perform in accordance with the reasonable expectations of users. CertainTeed asserts that the vast majority of the shingles are free of any defect and will last throughout the warranty period. The settlement provides additional compensation to certain homeowners without CertainTeed admitting fault, beyond the company's warranty terms. (Burney, 2010).
- In May 2010, a New York City-based concrete-testing company president was sentenced to prison for racketeering and forging concrete testing results for such projects as Ground Zero's skyscraper (Associated Press, 2010).
- A very recent BP explosion caused the death of several oil rig employees, and the ensuing oil spill in the Gulf of Mexico has wrought massive destruction on the ecosystem of the Gulf. To date, BP has set aside funds surpassing $2 billion for individuals, companies, and States impacted by the disaster. Shortcomings in corporate and Federal oversight are blamed for the incident, and joint cleanup efforts are currently underway across the Gulf (BP Press Office, 2010).

As this cursory sampling of contemporary incidents shows, overlooking the importance of quality checks and balances can lead to huge expenses, company closures, unsafe environments, illness, federal investigations, lawsuits, and even death. This report will synthesize key recommendations that can help IDOT maintain and improve current quality program efforts based on extensive research of contemporary and historical practices around the United States. These recommendations can help IDOT to expend resources more wisely and protect the lives of the motorists, pedestrians, and citizens who rely on the services that IDOT provides on a daily basis.

The benefit of hindsight can help us in many aspects of our lives. It can help us predict and prevent problems. It can also help us make adjustments and changes that can make our lives easier and less stressful. - Richard Carlson

INTRODUCTION

The Illinois transportation construction program costs approximately $2 billion dollars annually, and nearly half of that amount is spent on expenses for project materials. It is important to protect the state's transportation system investment and assure that quality materials and workmanship are provided to these projects. Recently, Mr. Thomas Harman, P.E., of the Federal Highway Administration (FHWA) delivered an educational talk at the University of Illinois Bituminous Conference wherein he openly discussed the Quality Assurance System for the United States and how the Code of Federal Regulations (CFR) guides National Highway Institute (NHI) construction projects. According to Mr. Harman, the CFR is an integral part of the foundation that must be laid for a successful road building system. An important aspect of the CFR is that investment in road building does not start or stop at any one point; rather, ingenuity continues through the evolution of the product, beyond production, and with personnel on an ongoing basis. Persistent reinvestment in the people, products, and procedures needed for a complete road program must be reviewed and discussed throughout the transportation industry. This research document will address these ongoing needs as we live through a changing business environment in Illinois.

As part of the effort to reduce the size of government, the staff in the Bureau of Materials and Physical Research (BMPR) at the Illinois Department of Transportation (IDOT) decreased from approximately 116 employees in 2002 to 67 employees in 2008. To maintain quality programs during this six-year transition, the BMPR pursued a series of productivity, outsourcing, and economizing efforts to reduce central laboratory, field sampling requirements, and staff levels for testing. IDOT is recognized as an organization with a rigorous quality program and limited fraud. However, with substantial staffing cuts to date and additional projected staff reductions, there is a very real possibility that IDOT could incur quality-related risks. These risks may compromise the safety of the user public and shorten transportation infrastructure performance life.

As succinctly stated by Mr. Hal Wakefield, P.E., Engineering Team Leader of the FHWA Illinois Division, "The BMPR is responsible for making sure that products used in highway construction in Illinois are acceptable. The primary mission is to establish tests and procedures to make sure that products provided by highway contractors comply with specification requirements". The roles and responsibilities of BMPR include: providing the IDOT Regional Engineers with assistance; ensuring that the overall Quality Assurance program is implemented according to the Code of Federal Regulations (CFR); and verifying that in-place materials are functioning as intended. To this end, BMPR works in tandem with many IDOT Bureaus, specifically with the Bureau of Construction, on the following action items:

1. Providing guidelines for project material certification reviews that are consistent with IDOT's current policies,
2. Examining a random selection of projects and test program areas to ensure compliance with established policies, and
3. Assisting Districts in addressing problem areas and in training State and local agency personnel to perform the project materials certification function.

To enhance the functions of statewide transportation operations, BMPR also provides oversight, assistance, and resources to local and district agencies upon request. Each item is discussed in further detail in the body of the report.

Guidance to state agencies to minimize risk is given through the FHWA QA Procedures for Construction. The purpose of the QA Procedures is to prescribe policies, procedures, and guidelines to assure the quality of materials and construction in all Federal-aid highway projects on the National Highway System (NHS). Each State Highway Authority (SHA) shall develop a QA program to assure that the materials and workmanship incorporated into each federal-aid

highway construction project on the NHS are in conformity with the requirements of the approved plans and specifications, including approved changes. The program must meet the criteria in CFR637.207 and attain approval from the FHWA.

To ensure continuity of definitions throughout this document and for use during the QA Peer Exchange, it is appropriate to list definitions at this point. In 2005, the Transportation Research Board (TRB) released a circular containing a glossary of highway QA terms (TRB, 2005). This document was developed to provide a uniform understanding of technical terms that have specific meanings in the highway engineering field. Definitions for these terms are cited below to introduce and clearly distinguish among them.

- **Quality Assurance (QA)** — All those planned and systematic actions necessary to provide confidence that a product or facility will perform satisfactorily in service. QA addresses the overall problem of obtaining the quality of a service, product, or facility in the most efficient, economical, and satisfactory manner possible. Within this broad context, QA involves continued evaluation of the activities of planning, design, development of plans and specifications, advertising and awarding of contracts, construction, and maintenance, as well as the interactions of these activities.
- **Quality Control (QC)** — Also called process control, QC includes those QA actions and considerations necessary to assess and adjust production and construction processes so as to control the level of quality being produced in the end product. QC is motivated by QA and acceptance procedures, and typically is the responsibility of the contractor and / or producer.
- **Inspection, Sampling, and Testing** — The act of examining, measuring, or testing to determine the degree of compliance with requirements.
- **Acceptance** — The process of deciding, through inspection, sampling, and testing, whether to accept or reject a product, including what pay factor to apply. Where contractor test results are used in the agency's acceptance decision, the acceptance process includes contractor testing, agency verification, and possible dispute resolution.
- **Independent Assurance (IA)** — A management tool that requires a third party, not directly responsible for process control or acceptance, to provide an independent assessment of the product or the reliability of test results, or both, obtained from process control and acceptance. The results of IA tests are not to be used as a basis of product acceptance.

QA is a process to ensure that the quality of the finished product meets specifications. It is the responsibility of the highway agency and consists of QC, inspection (sampling and testing), acceptance, and IA.

In its effort to limit quality-related risks, the BMPR maintains a comprehensive testing and evaluation policy that is outlined in their *Manual for Materials Inspection* and various reports, manuals, training courses, and guides. With the reduction in human resources at the BMPR, however, it is challenging to adequately cover all aspects of their testing and evaluation programs. The BMPR has many functions beyond the responsibility to inspect, sample, and test materials and implement a uniform system statewide. A brief, comprehensive list of BMPR activities required according to Federal mandates *Part 1 – Federal statues of the United States Code (USC), Title 23 (Highway)* follows (reference *Federal and State Mandates for Illinois BMPR* for complete listing) follows:

Statute	Requirement(s)	Bureau of Materials and Physical Research Actions
23 USC 109(a);(c)	Requires projects to provide safe highways; use of Federal, American Association of State Highway and Transportation Official (AASHTO) and other design standards and participation on standards committees	Adopts, uses, and revises Federal, AASHTO, and State standards and specifications; develops and maintains numerous policy memoranda and manuals; participates on national standards committees
23 USC144 (a-c)	Declares bridge rehabilitation and replacement to be vital to the national interest; requires inventory and classification of serviceability, safety, and essentiality; requires replacement costs be provided	Provides safety and material ratings to determine serviceability and replacement costs of deteriorated bridges; reviews material specifications; investigates cracking and failures (with B. of Bridges and Structures)
23 USC 302	Requires States to have a Department of Transportation (DOT) with adequate powers, suitably equipped and organized to discharge to the satisfaction of the Secretary of Transportation the duties required	Provides an adequate number of personnel to conduct required materials and research activities or engage consultants to perform needed duties; requires constant reinvestment in equipment, vigilant specification enhancements, and timely training of agency staff
23 USC 303(a)	Issues regulations requiring management of pavements, bridges, and highway safety	Has on-going bridge and highway safety projects; pavement management efforts include ride quality and friction testing
23 USC 402(a)	Requires State DOTs to have a safety program to reduce accidents, deaths, injuries, and property damage	Provides technical analysis as well as mixture performance and materials test data for pavements, barriers, guard rails, breakaway couplings, lighting, sign and signal structures, pavement markings, reflective sheeting, and deicing and anti-icing chemicals
23 USC 403 (f)	Provides for collaborative research for improvements in safety and marketing of new technology with various partners	Collaborates with universities, Federal, and State agencies, consultants, and corporations; evaluates new products and technologies
23 USC 502 (a)	Provides general authority for research, technology transfer activities, development in all phases of transportation; cooperative agreements and transactions with AASHTO, National Academies, etc.	Provides technical reports on all phases of pavements, bridges, and safety issues; participates on national committees and panels

Statute	Requirement(s)	Bureau of Materials and Physical Research Actions
23 USC 505 (b)	Requires States to devote at least 25% of State planning and research funds to research, development, and technology transfer	Has an active research program in compliance with Federal mandate
23 CFR 420.205	Provides information for peer exchanges; implements a process to assure the effective use of research, development, and technology transfer activities on a statewide basis	Maintains continual exchange of information with WI, MO, MI, IA, MN, OH, IN, and other RAC II Region States; identifies technical issues which impede research implementation, and addresses problem areas before they become critical; performs focused studies to arrive at conclusions; develops specifications and policies; aids in implementation by making presentations; develops and teaches classes; submits findings to the FHWA to share with other States
23 CFR 630.203	Requires plans, specifications, and estimates for projects to be submitted to the FHWA for approval	Provides material specifications and testing for aggregates, soils, cement, concrete, asphalt products, pavement markings, metals and miscellaneous materials, and other standard and experimental products; provides designs and specifications for machinery, and costs of construction for movable bridges
23 CFR 635.410 (Buy America Act)	Requires State DOTs to assure to the FHWA that steel and iron products are of domestic origin ; requires waiver submittal if domestic materials are insufficiently available or non-equivalent	Provides domestic sources to fabricators, contractors, and consultants for steel products; certifies by waiver when domestic steel or alloy is non-available or if foreign material is metallurgically equivalent

Statute	Requirement(s)	Bureau of Materials and Physical Research Actions
Public Law 101-592 (Fastener Quality Act)	Requires that fasteners used in critical applications conform to the specifications to which they are represented to be manufactured; requires accreditation of laboratories engaged in fastener testing, as well as inspection, testing, and certification in accordance with standardized methods	Continually tests and provides approved lots of domestic sources to fabricators and contractors for steel products; certifies by affidavit that the drawings / markings are representative of the indicated product and that they are manufactured using domestic steel
23 CFR 637, Subpart B	Assures the quality of materials and construction in all Federal-aid projects on NHS; requires the following: • Maintain a central laboratory accredited by AASHTO	Actively complies with 23 CFR 637 by prescribing policies, procedures, and guidelines. Furthermore: • BMPR's central lab is annually accredited under the AASHTO Materials Reference Lab in aggregate, soil, asphalt cement and emulsions, and HMA. Cement and Concrete Reference Laboratory (CCRL) for cements (chemical and physical tests) and concrete. It is AMRL assessed for metals, misc. materials, paints.
	• Maintain a quality assurance program, an independent assurance program, verification sampling and testing, and random sampling	• Develops, evaluates, and monitors statewide materials control programs that dictate Departmental materials sampling, testing, and acceptance procedures. Materials control programs incorporate QA, independent assurance, verification sampling and testing, random sampling at producer's or project sites. • Develops, disseminates information statewide on materials control programs through *Project Procedures Guide (MAT-9)*, *Highway Subgrade Stability Manual (MAT-10)*, *Manual for Materials Inspection (MAT-11)*, *Manual of Test Procedures for Materials (MAT-13)*, *Geotechnical Manual (MAT-14)*, policy memoranda.

Statute	Requirement(s)	Bureau of Materials and Physical Research Actions
23 CFR 637, Subpart B, cont'd.	• Conduct all materials sampling and testing by qualified laboratories	• Conducts a lab inspection program (district, branch, and private laboratories) and round-robin materials testing to ensure qualified labs. Due to AASHTO and ASTM requirements, BMPR is the sole testing facility for certain materials. • Maintains statewide database of qualified laboratories.
	• Conduct all materials sampling and testing by qualified personnel	• Developed initial Trained Technician Program. Annually reviews and administers Trained Technician Program to State, contractor, consultant, and local agency personnel, to ensure qualified materials testing personnel. • Maintains statewide database of qualified personnel.
23 CFR 655, Subpart F	Prescribes policies and procedures to obtain basic uniformity of traffic control devices on all streets and highways in accordance with the FHWA-approved references	Tests reflective signing and pavement marking materials for color, reflectivity, and general compliance with the FHWA-issued Manual on Uniform Traffic Control Devices (MUTCD)

As indicated, there have been efforts to economize the testing and evaluation procedures as well as the testing units. Another step in the process is to understand how other state DOTs focus their limited staff to avoid performance risks. It may be possible to limit the risk of bridge, pavement, and appurtenance failures in Illinois due to non-conforming materials by analyzing how the internal testing and evaluation programs in other states have been:

- maintained
- modified
- expanded
- reduced
- eliminated

In lieu of adding staff to limit the risk of failure, additional QC by the contractor and material supplier, QA by resident engineering staff, and outsourcing just-in-time inspection to engineering consultants may be required.

WORK PLAN OBJECTIVES OVERVIEW

The proposed work plan for this research consisted of three phases to help IDOT continue evolving to ensure that the highest level of quality measures is maintained going forward.

Phase 1: Information Gathering

Phase 1 consisted of three defined information-gathering tasks:

Task 1: Review of IDOT testing and evaluation procedures, policies, and practices to determine areas for analysis.

Task 2: Interviews with IDOT Central and District Laboratory units and the Bureaus of Bridges and Structures and Construction on current testing and evaluation programs.

Task 3: Research on the select practices of other lead States.

Phase 2: Multi-State Peer Exchange and Materials Testing Workshop

Phase 2 used the information gathered in Phase 1 to organize and conduct a Multi-State Peer Exchange and Materials Testing Workshop with representatives from four states with practices that could potentially benefit IDOT, as well as representatives from the FHWA. The few selected attendees maximized discussion and interaction between participants regarding specific subject matter.

Phase 3: Summarizing the Findings

Phase 3 is this final report and accompanying documentation summarizing the findings of the study phases, including follow-up with IDOT and key states that participated in the Multi-State Peer Exchange and Materials Testing Workshop.

A credible and critical ***risk assessment*** is part of the successful application of this research study.

The following document details the information gathering results of this research effort and indicates the need for further investigation for a full understanding of the national implications of IDOT's processes. Great efforts and valuable input from the IDOT BMPR, District Materials Engineers, FHWA, and private industry have led to a series of recommendations, which are presented in this report and as a comprehensive list in the conclusion of this paper.

PHASE 1 INFORMATION GATHERING

Initially, project activities focused on gathering information from the IDOT Central Laboratory, Bridges and Structures, and Construction, IDOT Districts, and selected key state DOTs to determine areas for enhancement to improve the way that transportation business is conducted in Illinois. This effort was accomplished by the research team through the following three tasks:

Task 1: Review of IDOT testing and evaluation procedures, policies, and practices to determine areas for analysis.

Task 2: Interviews with IDOT Central and District Laboratory units and the Bureaus of Bridges and Structures and Construction on current testing and evaluation programs.

Task 3: Research on the select practices of other lead states.

These tasks are elaborated on in the first section of this report.

1.1 TASK 1: REVIEW

Task 1 involved researching and documenting existing IDOT testing and evaluation procedures, policies, and practices. A comprehensive review of the various publication materials used by IDOT for testing, evaluation of construction materials, and procedures follows.

The *Manual for Materials Inspection* (January 1, 2007) provided an excellent starting point for this study task. Based on a review of the manual, the method of acceptance for most materials appears to be based on individual application or application of a combination of the following:

- CERT – Manufacturer's certification indicating compliance of material to specifications.
- LIST – Material required to appear on a current list of IDOT approved products.
- QC / QA – Quality control / quality assurance inspection required.
- QUAL – Material required to be manufactured by a qualified / certified producer.
- TEST – Testing required by IDOT BMPR or District Bureau of Materials.
- VIS – A visual examination for acceptance or rejection of material.

Other IDOT guides, manuals, and reports relating to materials testing and evaluation were reviewed under this study task. As Figure 2 shows, the IDOT BMPR offers a fairly comprehensive list of resources, including guides, guidelines, manuals, MISTIC Reports, and other information regarding materials acceptance on their website, a valuable resource that the BMPR should continue to enhance and promote. The various material groups and acceptance requirements are discussed in terms of their impact on IDOT operations and construction quality.

ILLINOIS DEPARTMENT OF TRANSPORTATION
BUREAU OF MATERIALS & PHYSICAL RESEARCH

The Bureau of Materials and Physical Research publishes guides, manuals, MISTIC reports and miscellaneous supplemental documents that provide assistance to Department personnel, material producers/suppliers and contractors regarding the procedures/programs used to accept/approve certain materials.

Guides
Fastener Identification (10/03/08)
The Fastener Identification Guide is a list of markings for producers that have provided approved fasteners in the past. Fasteners are approved by testing on each lot.

Mechanical Reinforcing Bar Splicers/Coupler Systems (03/21/08)
The Identification Guide for Mechanical Reinforcing Bar Splicers/Coupler Systems is a list of approved producer systems and designs along with their product markings that are currently approved by the Department.

Project Procedures Guide (PPG) (03/01/06)
Materials sampling and testing guide. Click PPG to go to the web page.

Rebar/Dowel Producer Identification (05/23/08)
The Identification Guide for Certified Reinforcement Rebar/Dowel Producers is a list of markings for rebar/dowel producers that are currently operating under the department's certification program.

Manuals
2009 Manual for Fabrication of Precast Prestressed Products (12/05/08)
This manual provides a source of reference and guidelines for those involved in the inspection, fabrication, and storage of precast prestressed concrete products. It has been prepared with major emphasis on details, practices, and procedures currently being used in the industry. In addition to fabrication techniques, the Manual addresses permissible repair procedures and handling, storage, and transportation of precast prestressed concrete products. Previous Release: 2007 Manual for Fabrication of Precast Prestressed Products (01/01/07) and Addendum to 2007 Manual for Fabrication of Precast Prestressed Products (05/20/08)

IDOT Inspectors (05/23/08)

Consultant Inspectors (06/13/08)

MISTIC Reports
MISTIC Material Code List (08/05/08)
Alphabetic and numeric listings of material codes.

MISTIC Producer List (08/05/08)
Alphabetic and numeric listings of materials. producer/suppliers.

MISTIC Pay Item/Material Conversion Factor Report (09/04/08)

- Listing of pay item unit of measure to material code unit conversion factors in pay item order.

Photographs
Corrugated Metal Pipe (02/27/08)
Detailed satisfactory and unsatisfactory photographs of corrugated metal pipe.

Precast Concrete Product Defects (3.7 MB)
Photographs detailed defects and rejections of precast products

Portland Cement Concrete (PCC) Mix Design Spreadsheet
This spreadsheet is designed to assist users in calculating PCC mix designs for submittal to IDOT. The following five files are included in the downloadable file below:

Figure 2. Excerpt from the extensive resource list available on the IDOT BMPR website.

It is important to note that IDOT BMPR and the District Material Bureaus continually develop and deliver an assurance program to keep up with changing scientific practices. For example, when new equipment is developed that provides for quick, accurate, and easy to interpret data specific to the quality of a product, IDOT typically validates and purchases the piece of equipment to improve their program. One specific opportunity was the Hamburg Wheel tester, used successfully around the nation, which validates the ability for Hot Mix Asphalt (HMA) pavements to carry traffic loading and predict pavement performance specific to deformation (rutting) and stripping.

Understanding of statistics continues to help guide IDOT's current and future acceptance program. Several definitions to help with this process follow:

- **Risk** – Event, which is uncertain and has a negative impact on some endeavor.
- **Risk analysis** – Process of quantitatively or qualitatively assessing risks. (This involves an estimation of both the uncertainty of the risk and of its impact.)
- **Risk management** – Practice of using risk analysis to devise management strategies to reduce or ameliorate risk.
- **First Article** – First article testing and approval ensures that the contractor can furnish a product that conforms to all contract requirements for acceptance.
- **Risk Based Decision Making (RBDM)** – Decision processes that are repeatable, consistent, and defendable that is used within IDOT's resource allocation model.
- **Redeploy** – Distribute key employees systematically or strategically.

Risk is a multifaceted issue and must be addressed with methods that are appropriate for the decisions being made. Historically, risk assessment and risk management professionals have focused on accident risks, natural hazard risks, business interruption risks, project risks, and financial risks. In these areas, organizations have used systematic processes and tools to understand and prioritize these diverse risks (especially those with catastrophic consequences) so that limited resources can be effectively applied to reduce risk. Figure 3 characterizes the foundational elements for developing an understanding of risks so that they can be effectively managed.

Figure 3. Chart of risk understanding and risk assessment (Mitchell and Decker, 2004).

Industry experts, such as Baker Engineering and Risk Consultants, Inc., engage in Quantitative Risk Analysis (QRA) as an ongoing process. State agencies can benefit from the strengths of these existing systems. QRAs provide numerical estimates to allow clients to understand risk exposure to areas of interest, such as people, business, or the environment. Risk-Based Decision Making (RBDM) is essentially a series of basic steps that streamlines the decision-making process with a focus on events with a high degree of uncertainty and the potential for catastrophic outcome. RBDM is a valuable process that can save time and money when an organization faces multiple scenarios with varying degrees of uncertainty and impact on performance objectives.

Risk Analysis Systems can identify potential gaps in an existing decision-making process, and assist in developing and implementing policies and procedures to close these gaps. The end result of this effort should be an orderly, streamlined process that provides the following benefits:

- More consistent and transparent decision making
- Reduction in the number of unresolved items
- Clear justification for not pursing a course of action
- Discussion centered around specific assumption instead of generalities
- Clarity in the decision-making process and more expedient decision-making
- Better management of limited resources
- Better alignment between operating units and overall performance objectives.

Today, “first article” can be applied by IDOT as it is inclusive of a new vendor / old vendor with past problems or who had discontinued supply, manufacturing process changes, and / or specification changes. In the construction of HMA or Portland Cement Concrete (PCC), this overload of effort is called a test strip. Testing looks at materials, machinery, and methods under great—and justifiable—scrutiny, quite often on a project-by-project basis. The risk of the material failing to meet specification and the consequences if the material fails to meet this specification (Risk Understanding) was an item explored with QA Peer Exchange participants. The efforts put forth with this research are beneficial to BMPR as well as the Bureau of Construction as understanding and anticipating elements of project management risk analysis lead to optimum:

1. Schedule. Will the project be completed on time?
2. Cost. Will the project be built within budget?
3. Performance. Will the output satisfy the goal(s) of the project?

Historical experience is a combination of documented individual personnel experiences and numerical analysis of inspection, sampling, and testing performed (analytical methods). Documents compiled with the benefit of analytical data, engineering expertise, and scientific knowledge, coupled with dialogue, intuition, and anecdotal evidence, have led to a series of IDOT policy memorandums. An amalgamation of the surrounding State materials requirements was compiled and expanded on through the hosting of the QA Peer Exchange at the BMPR in October 2009.

At the QA Peer Exchange, to determine the processes of the visiting States and further drill down into their subtly different styles of documentation, dialogue, and implementation, the acronym D.R.I.L.L. was used to describe a process that encompasses the following action items:

- Dive into minutiae
- Recognize opportunities
- Identify action items
- Learn from others
- Lead from learning

There is a potentially endless list of strengths and weaknesses to pursue in the current QA system, unless IDOT develops a risk matrix (or grouping) that acknowledges both the potential for a material to fail to meet specification requirements and the magnitude (consequences) of the failure to the motoring public. The matrix is designed and developed as follows:

- Cross-section of experts (design to construction) rank products.
- Multiple Delphi iterations of rankings is performed. (Risk versus consequences of failure to meet specification.)
- Group of agency employees works towards consensus.
- BMPR is the gatekeeper and shall provide continuous validation / enhancements of matrix.

In engineering design, reliability estimates of different parts are combined with an assessment of the impact on system performance of the failure of the parts. This analysis has in turn been used to direct resources for modification and redesign to those areas of complex man-made systems, where improvements have the most effect on reducing potential failures. In this case, we will enhance the review after developing our matrix on service versus criticality. Unfortunately, material defects have become so prevalent that recently the American Society of Civil Engineers (ASCE) formed Committee E58 to develop standards that support engineering investigations and assist the court by bringing engineering reason to the dispute resolution process. According to ASCE, “Forensic engineering focuses on the investigation of alleged defects in materials, products, structures and components. These cases are litigated on the premise that the defects cause personal injury or damage to property. Forensic engineering investigations may help determine the causes of these events and assist the disputing parties or the court in resolving the case. Today, forensic engineers are involved in a broad range of investigations across numerous engineering disciplines, including aerospace, biomechanical, chemical, civil, electrical, fire, industrial, manufacturing, transportation and many others.”

Figure 4, drawn from current Washington State DOT acceptance methods, is based upon the two risk factors (chance versus consequences) and four levels of materials acceptance (highest to lowest).

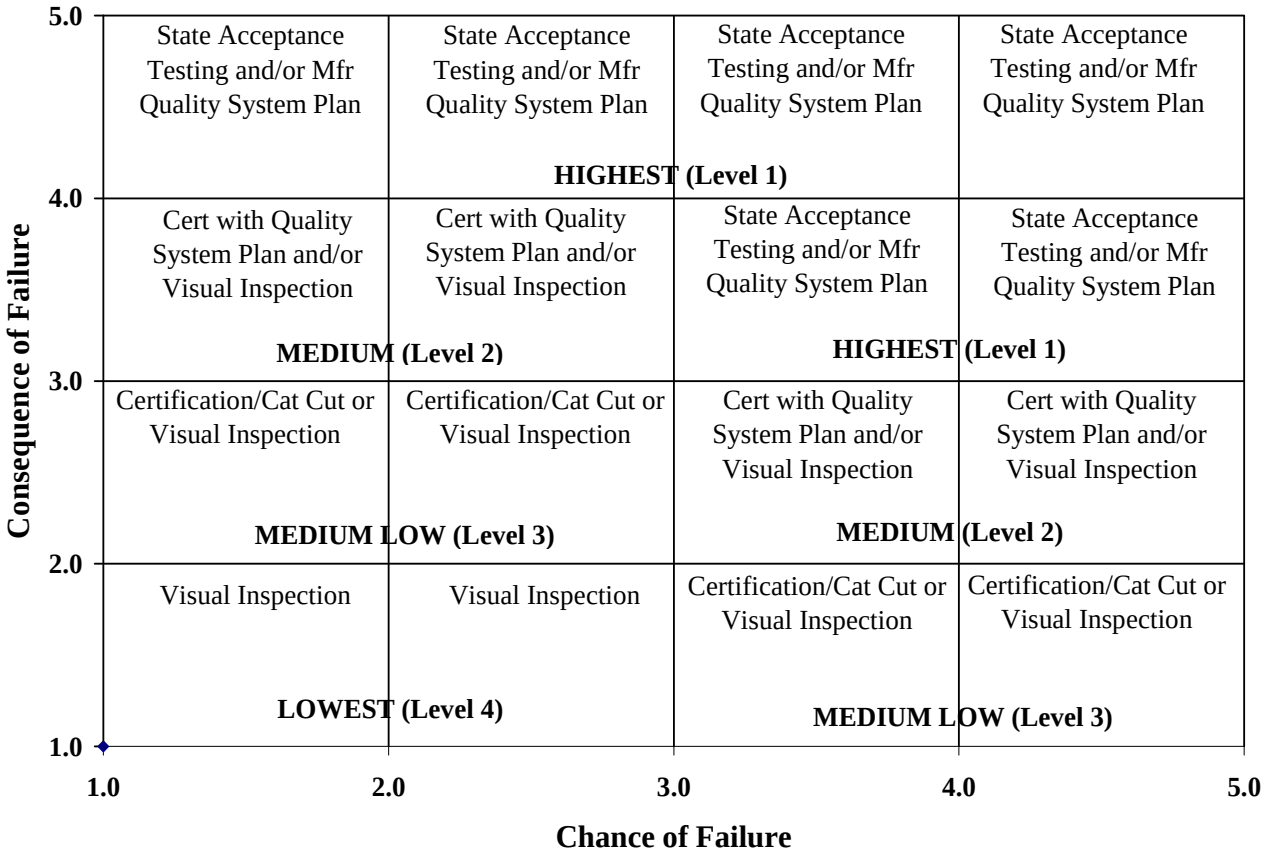


Figure 4. Levels for Materials Acceptance Rating Matrix (Baker et. al., 2006).

As figure 4 demonstrates, IDOT should establish (and maintain defined) levels of materials examination to determine the quality of any given material, from the most intensive level of scrutiny to the least. For example, ratings could include the following:

- Highest (Level 1) – SHA acceptance testing, or a combination of fabrication inspection coupled with a requirement for a manufacturer's quality system plan.
- Second highest (Level 2) – Requires a manufacturer's certification of compliance with a quality systems plan.
- Intermediate (Level 3) – Either a manufacturer's certification of compliance or a catalog cut stating the qualities of the material being used.
- Lowest (Level 4) – Visual inspection in the field.

A quality improvement team is a group of experts that should get together at least annually to audit and suggest improvements to the system and publish their findings. IDOT continues to review and revisit acceptance procedures; however the last documented improvement of the certification of materials process through the implementation of Total Quality Management (TQM) was published in February 1996 for IDOT.

As figure 5, specific to chemical items, illustrates, both chances for failure and the consequences of failure are low for traffic paint, but higher for epoxy resin. Further review of the data indicates a strong opportunity for the reduction in sampling and testing of roadway paints, while maintaining a reduced schedule of random sampling to ensure quality, whereas the occasions for reviewing epoxy resin could increase to reduce problematic outcomes.

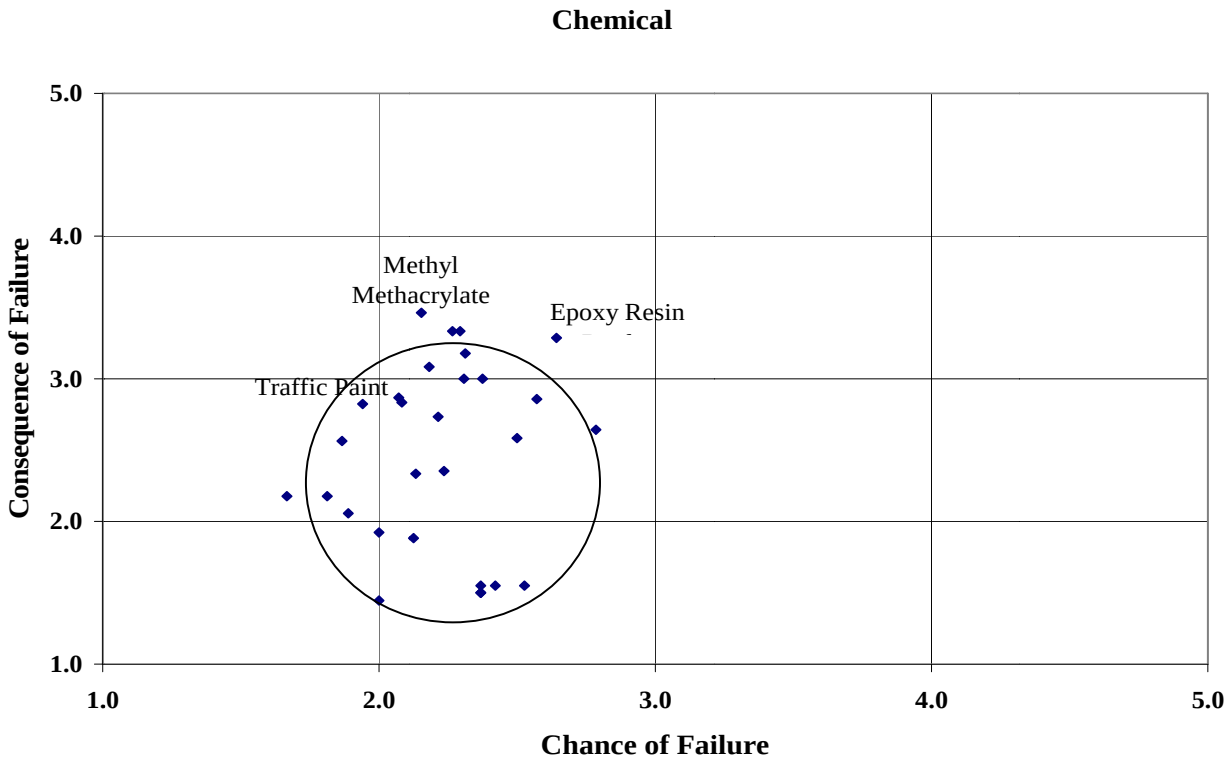


Figure 5. Chance versus consequences analysis for chemical items (Baker et. al., 2006).

As IDOT works through the matrix process, they will need to apply the type of analysis shown in figure 5 to every product they have, including materials as diverse as grass seeds, glass beads, and liquid asphalts, and devise a tiered pay scale accordingly in lieu of the standard cliff payment policy (an all-or-nothing system that fails to adequately address risk and reward). Figure 6 shows the comparison between a typical tiered pay scale and the standard cliff payment policy.

Figure 6. Step payment policy compared to cliff payment policy.

As producers are evaluated, if their percentage of compliant product increases, then a logical next step is to reduce the amount of acceptance testing at that source. The end result of these analytical steps and managerial decisions will most likely lead to a redeployment of personnel to lesser manufacturing sources and / or allow BMPR and all Districts to increase their examination of a random selection of projects and test program areas to ensure compliance with established policies. This will not compromise the overall QA program. During the National Transportation Product Evaluation Program (NTPEP) conference, discussed later in this report, it became clear that there is a need to eliminate annual or tri-annual visits to steel manufacturers who do little to no work with IDOT. This item is in keeping with the BMPR goals and objectives as understood from prior conversations with upper management.

Placing the annual plant inspections with NTPEP actually increases BMPR activities within Illinois and reduces time away from the office spent dealing with vendors who are 'after the IDOT stamp of approval for marketing purposes only.' Focused QA within Illinois, at Illinois vendor locations, will increase the percentage of material acceptance and forge ever-improving relationships between BMPR and Illinois vendors. In addition, the increase to unit head time in the office working with their staff will invariably allow the managers added opportunity to work with and oversee employees. This should include cross-training which will improve employee skill sets. For example, the BMPR will be able to coordinate all reinforcement bar sampling and testing in-house and modify District mandated participation per policy memorandum 25-08.2 which will improve the current overall QA process for IDOT at no added cost but with increased efficiency.

Prior to NTPEP representatives visiting Illinois to further discuss their roles and responsibilities with BMPR upper management, section heads, and IDOT frontline workers, Mr. Doug Dirks of IDOT expressed interest in developing a regional materials acceptance process for cements that will require sharing of test results across State lines. This deficiency in sharing results exists nationally, so NTPEP representatives who visited Illinois agreed to develop and implement an improved method of sharing test data across State lines. Mr. Dirks had a meeting in October 2009 where he began to get an audience to begin this effort and he reported such during the Peer Exchange. IDOT and other state engineers should champion this cause as it holds promise to provide the greatest payback on increased quality assurance by reducing costs as SHA sampling and testing are shared electronically. Missouri Department of Transportation (MoDOT) representatives agreed to work with Mr. Dirks on this effort.

Furthermore, Mr. Dirks pointed out that the Midwest Concrete Consortium would be a useful conduit for inspecting, sampling, testing, and sharing information at a regional level. Alongside a review of current IDOT and surrounding State QA programs, it became important to coordinate and visit with various agency and private organizations to gain an understanding of the practical implementation of the acceptance programs as written. The resulting interviews were part of Phase 1, Task 2, which is elaborated in the following section.

1.2 TASK 2: INTERVIEWS

Task 2 involved extensive interviews with IDOT Central and District Laboratory units and the Bureaus of Bridges and Structures and Construction on current testing and evaluation programs. Visits to the IDOT Central and District Laboratory Units to identify and document the testing and evaluation units included the following items of interest:

- Frequency of testing
- Work load during peak and off peak periods
- Number of people involved
- Scheduling strategies
- Laboratory facilities
- Space requirements and use
- Data management
- Operational procedures.

A major effort was made to determine how the various laboratory units contribute to the overall quality of the IDOT materials and construction program. There was some effort to look at the cost to benefit ratio that the testing units bring to IDOT, local agencies, the tollway, and private sector, as well as the role they play in risk reduction. The testing unit staffing levels were a priority item from the standpoint of staff reduction or staff increases, as necessary for safety and operational cost-effectiveness. IDOT has made a major effort to increase productivity and streamline their testing units over the years; additional recommendations to enhance this effort for IDOT have become evident. This study task was conducted through coordination with IDOT staff, with a high degree of interaction with IDOT employees.

1.2.1 Kick-Off Meeting with Bureau of Materials and Physical Research (BMPR)

A kick off meeting held at the BMPR on April 14, 2009, included discussions centered on risk mitigation with Section Heads as well as a laboratory tour. The mission and vision of the BMPR may be summed up in the following way: BMPR is the heart of IDOT that exists to maintain, sustain, and grow the ability to be the experts for all road and bridge construction components, from analysis through long-term performance. BMPR Section Heads operate in an environment focused on Risk Management Processes daily and work with their staff to ensure competency of inspection, sampling, and testing efforts and compliance to the Code of Federal Regulations. An open discussion on existing as well as future work efforts specific to key elements of managing risks of any type and a discussion of effective control of risks ensued; thus, risk management became the theme of this kick-off meeting.

Figure 7. Cyclical nature of the risk management process (FHWA, 2006).

The BMPR Section Heads are:

- S. Beshears – Aggregates
- J. Trepanier – Hot Mix Asphalt
- D. Dirks – Concrete, Cement, Soils, Nuclear
- E. Hughes – Metals and Miscellaneous
- V. Prill – Chemicals

Each Section Head gave laboratory tours and discussed their efforts undertaken in preparation for the upcoming Multi-State Peer Exchange. Then, each Section Head selected several items specific to their unit for discussion. The agenda for the day helped maintain focus on the following questions:

1. What test(s) use the most manpower?
2. What test(s) are only done here?
3. What test(s) could be done anywhere besides here?
4. What test(s) require special equipment?
5. What test(s) don't control our *risk*?

Section Heads discussed strengths and weaknesses of the acceptance program with their list of goals for future direction of their respective sections. The presentations of each Section Head given at the Peer Exchange are included in Appendix 1.

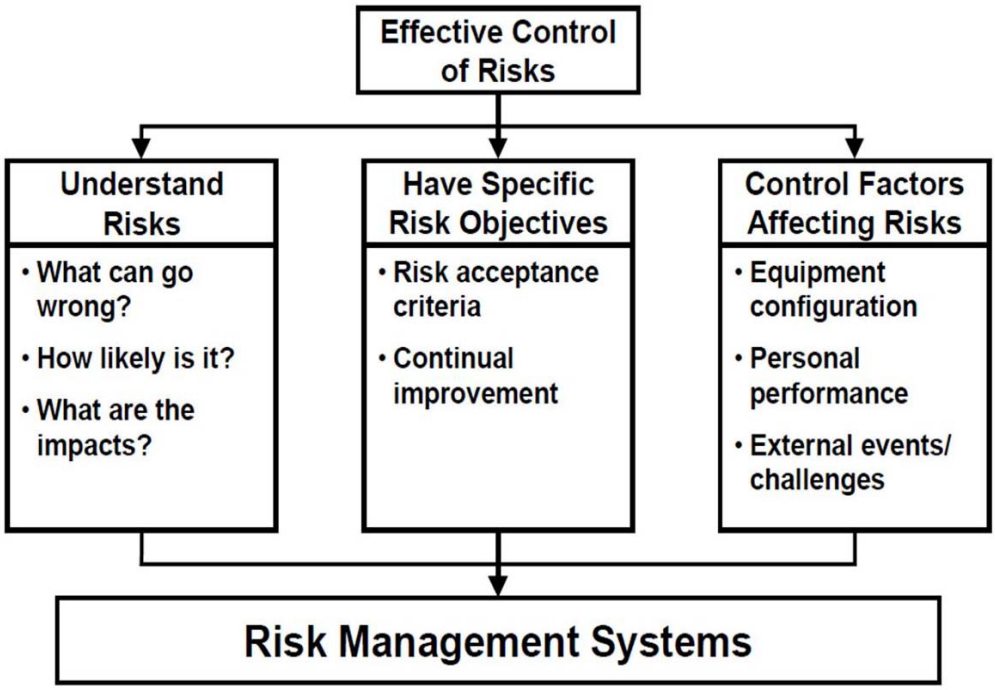


Figure 8. Key elements of managing any type(s) of risk(s) (Mitchell, 2001).

The BMPR kick-off meeting was used to further provide guidance for research and preparation for the QA Peer Exchange.

The key items brought up by each Section Head included:

- S. Beshears – Micro Duval for aggregates and RAP; can it replace soundness and abrasion?
- J. Trepanier – Behind the paver sampling; will it measure quality most accurately?
- D. Dirks (by Lippert) – Cement; what is your frequency and how can we capture data from work done by other agencies from the same source?

- E. Hughes – Foreign steel; how do others educate construction personnel to ensure compliance? Bearing pads and pastic pipe; are you testing?
- V. Prill – Bridge paints, crack sealant, and pavement markings; what is NTPEP's role and can they help us?

At this meeting, the investigators requested a list of assets (equipment and property), detailed information on how time sheets are completed by the frontline workforce (details will establish time, effort, energy, and cost to perform a test), and a comprehensive summary of percentage of failures to tests taken on as many materials as possible. The complete meeting summary is found in Appendix 2.

One research objective is to provide guidance on the technical basis for, and the use of, Specification Conformity Analysis (SCA) procedures, used to estimate the degree of compliance with specifications and to provide an indication of construction quality for roadway materials used in Illinois and nationally. The SCA procedure is used in construction monitoring programs on a State-by-State basis where individual specification limits are held constant. The SCA procedure is also used by some states as an indicator of contractor performance in meeting specifications and / or as a basis for pay factor incentive and disincentive systems. In these cases, the specifications, sampling and testing programs, and contract documents have been written based on this type of acceptance. The concepts of the SCA procedure are consistent with those used in the AASHTO Guide Specification R9-86, "Standard Recommended Practice for Acceptance Sampling Plans for Highway Construction" (2005). Some of the merits of the procedure include that SCA:

- Can be effectively used to estimate the degree of conformity to specification. requirements that is being achieved on a project or for a particular construction process.
- Can identify specification requirements which are impractical or ineffectual in assuring good performance.
- Is useful for relating the degree of conformity to specifications with product performance.
- Is useful for evaluating contractors' process control capabilities.
- Is useful for monitoring the degree of control over a period of time.
- Can be used to determine when to increase or decrease sampling and testing frequencies from the approved frequencies.
- Is being used successfully by some States and on Direct Federal projects in specifications for the acceptance of materials, most notably asphalt concrete.

When properly used, the SCA procedure gives an estimate of the degree of conformity to specification requirements for the construction process and / or material to which it is applied. The test results and / or measurements used in the SCA should be randomly selected and accurate for the results to be totally valid. To infer whether or not good performance is likely to result, the measured attributes and the specification requirements must be related to the properties that control performance. Care must be exercised when comparing SCA results among processes, projects, or States. Comparisons are invalid unless the same specification requirements have been used in the individual analyses.

As the highlighted section in Figure 9 shows, specification criteria can be overly restrictive or meaningless as related to performance; despite a low quality level, overall performance can be good. As a recent example, reinforcement bars produced at Nucor Steel and epoxy coated by others failed multiple IDOT bend tests. IDOT's solution was to adopt A706 in place of A615 steel for use on future projects. A706 costs approximately $2.00 per 100 weight, or an equivalent of $40 per ton. While this upgrade seemed like a reasonable measure at the time, and although some states use A706, perhaps a more cost-effective alternative was available. In this specific case, IDOT may have been able to avoid failures by changing the QC system rather than by exclusively purchasing the more expensive A706 product. Without a timely, documented risk-analysis, this suggestion remains inconclusive, but an effective QC

system would likely prove to be an efficient and cost-reducing approach, or at the very least would validate the decision to upgrade to the purchase of A706 steel.

Process for Relating Calculated Percent Conformity (P_t)

QUALITY LEVEL	QUALITY OF DESIGN	ACTUAL LOAD APPLICATIONS	SERVICE CONDITIONS	END PRODUCT PERFORMANCE	PROBABLE CAUSE
Low	Proven	As Designed	As Designed	Poor	Nonspecification Compliance
High	Proven	As Designed	As Designed	Poor	Specification criteria meaningless as related to performance
High	Questionable	As Designed	As Designed	Poor	Design process is not valid
High	Proven	Unknown	As Designed	Poor	Likely related to overstressing
Low	Proven	As Designed	As Designed	Good	Specification criteria likely over restrictive or meaningless as related to performance
High	Proven	As Designed	As Designed	Good	Well-designed system

Figure 9. Process for relating quality, performance, and cause (Baker et al., 2006).

In Illinois, the use of Materials Integrated System for Test Information and Communication (MISTIC) is an accumulation of sampling and testing data (acquisition and warehousing) on an ongoing basis to:

- Document that test results and frequencies have been achieved for a project, (Browsing data facilitates project finalization and acceptance by the FHWA.)
- Analyze and adjust specification limits being used for material acceptance, (Querying data facilitates specification updates.)
- Observe trends, frequencies of compliance, and failure of materials being produced. (Exporting and analyzing data facilitates objectives for increasing or decreasing sampling and testing for a product from a vendor.)

Understanding the potential power of MISTIC, complemented by Statistical Analysis Software (SAS), is important for this QA Peer Exchange effort and outcome because the acceptance of materials through testing can be adjusted (i.e., reduce testing frequency) for materials with a history of uniform test results that show a good quality material. An historical example at our fingertips is Material Service Thornton, Illinois, specific to aggregate quality measures, where historical values may allow for reduced sampling and testing by IDOT and increased by the aggregate source.

It is recommended that IDOT continue to generate MISTIC reports for some random materials from the various BMPR and District sections for continued review and acceptance testing modification. Data of materials sampled and tested to export and analyze would include:

- Liquid asphalt,
- Paint,
- Aggregate qualities; source specific,
- Rebar,
- Dowel Bars,
- Cement,
- Geotextiles,
- Steel strands,
- Precast Prestressed Concrete 'I' beams,
- Nuts and bolts (fasteners).

The use of MISTIC and SAS to assist IDOT with their practical SCA effort is as prompt as any other State reviewed; however, accessibility to these electronic resources is limited. Many other States have begun to integrate and manage data through the use of SiteManager. SiteManager is a comprehensive client / server based construction management tool. It provides for data entry, tracking, reporting, and analysis of contract data from contract award through finalization. SiteManager is built on the same multi-tier architecture as the rest of the Trns•port suite, allowing for easy integration and data transfer throughout the States shown in Figure 10. It can be used by all levels of construction and materials personnel, including field inspectors, technicians, project managers, clerks, auditors, lab personnel, management, producer/suppliers, contractors, and the FHWA.

SiteManager has the following main functions:

- Contract Administration
- Contract Records
- Daily Work Reports
- Contractor Payments
- Materials Management
    - Provides recording, tracking and reporting of material samples, and test results from job sites, plants, and test labs.
    - Develops comprehensive lists that are included for reference and validation of data, including materials, lab qualifications, testing personnel, approved material lists, producer/suppliers, calibrated equipment, welders, and inspectors.
    - Supports aggregate, concrete, and bituminous concrete mix designs.
    - Allows user developed features such as providing sampling and testing requirements for contracts, and reporting of the status of tested materials for a contract.
- Laboratory Inventory Management System (LIMS)

Additionally, Messrs. Mueller and Murphy met with the Central Office Bureau of Bridges and Structures (BBS) on April 14, 2009 to review their ongoing acceptance procedures. The BBS is currently, and has been for quite some time, covering acceptance with in-house personnel as best practical and through hiring consultant companies as supplemental staff on an as-needed basis. They have four or five consultants under contract for any given year, each working with a $300k fiscal year budget. The BBS handles acceptance by following the American Association of State Highway and Transportation Officials (AASHTO) / National Steel Bridge Alliance (NSBA) Steel Bridge Collaboration Guideline documents listed below:

- *Sample Owners Quality Assurance Manual (G4.4 – 2006)*,
- *Steel Bridge Fabrication Guide Specification (S2.1 – 2002)*,
- *Steel Bridge Fabrication QC / QA Guide Specification (S4.1 – 2002)*.

Figure 10. Map of SiteManager licensing status across the United States.

Whenever practical they work out agreements with other governmental agencies to perform acceptance of steel produced at a great distance from Illinois borders and as the work load increases they quite often do not perform acceptance of non-structural, non-critical items. Currently, as a courtesy to local agencies they will provide acceptance services if materials are substantial and being produced at the same time as for IDOT projects. The BBS performs all independent assurance audits in house at this time.

Communication of fabrication inspection acceptance or rejection is handled throughout IDOT via several BBS Memorandums. Fabrication Inspection BBS Form 59 Releases are typically used for the following:

- Fabricated steel plate girders and wide flange beams,
- Miscellaneous structural steel, e.g., cross frames, diaphragms, bearing extensions,
- Overhead sign structures (simple span, single or dual cantilever, aluminum or steel),
- Bridge mounted sign structures (which may be waived to the Resident Engineer),
- Finger plate expansion joints and steel drain trough supports,
- Pot bearings (fixed and expansion),
- Modular expansion joints,
- Fixed bearings (especially built-up type such as required on railroad structures),
- Bridge pins and / or link plates,
- Prefabricated pedestrian / bicycle trusses (usually based upon local agency request),
- Specialty items involving significant fabrication (e.g., ferry docks, semi-permanent steel shoring, and moveable bridge components).

Fabrication Inspection BBS Form 59 Releases may be provided for the following:

- Repair steel, especially indefinite quantities of small items determined during construction,
- Special platforms and stairways such as for pump houses and gauging stations,
- Seismic bearings incorporating complex weldments,
- Built-up (welded fabrication) soldier piles or other foundation elements,
- Specially designed railings (aesthetic installation or unique load requirements).

Fabrication Inspection BBS Form 59 Releases are not typically provided for the following:

- Precast, prestressed deck planks and Bulb-T, I and deck –beams,

- Precast concrete box culverts, three sided structures, mechanically stabilized earth walls, tieback walls (rolled beam soldier piles, precast concrete panels, tendon assemblies), monotube sign structures,
- Traffic signal mast arms and signal poles,
- High mast light towers and light poles,
- Screw-in metal foundations for light poles,
- Neoprene sheets for finger plate troughs and behind semi-integral abutments,
- Connection plates for neoprene sheets behind semi-integral abutments,
- Elastomeric bearings,
- Anchor bolts (bearings, railings, neoprene joints, etc.),
- Metal deck forms,
- Noise walls (steel columns and precast concrete in-fill panels / metal panels / wood),
- Temporary shoring / jacking and cribbing owned by the contractor
- Cast iron, fabricated steel or plastic scuppers,
- Drain piping, downspouts, and drainage collectors,
- Navigation lights and mounting hardware (including platforms and / or ladders),
- Steel and aluminum bridge, pedestrian and bicycle railing (special designs may be inspected),
- Pre-fabricated inspection platforms and access ladders,
- Bridge joint sealing system (preformed joint seal [PJS], strip seal, neoprene expansion joint),
- Miscellaneous steel items (e.g., PJS joint armor plates, rail post anchorages, drain supports, parapet and walkway joint armor plates),
- Break-away wide flange and tubular sign posts,
- Wide flange beams for terminal pavement joints,
- Foundation piling, including steel H, precast concrete and steel shells.

Most of these items and their importance to the road building efforts were repeated by participants to the Peer Exchange. Some of the States handle the acceptance in-house, some with a blend of in-house and consultants, and one (New Hampshire) detailed how structural steel inspection is handled entirely by consultants. An example of having the ability to use consultants 'just in time' is the Stimulus Bill (American Recovery and Reinvestment Act) signed into law by Congress and President Barack Obama in 2009. The Department reacted quickly and efficiently to use supplemental staff during this peak of roadway construction and acceptance work was performed with consultants with some degree of success. With the current level of staff and the continued ongoing Accelerated Construction Program (ACP), IDOT has few options other than to continue hiring supplemental staff for the near future.

1.2.2 Corporate, State, and District Office Visits

Several visits to IDOT District offices, corporate offices of private industry, and material producers within Illinois were facilitated by BMPR with the intent of fact finding at various points throughout the State. District 1 provided feedback specific to current policies for testing aggregates, Performance Grade (PG) binders, cement, and dowel bars. Private industry visits included Hamilton-Sundstrand (A United Technologies Company) in Rockford, Illinois, GeoSynthetics, Inc. in Waukesha, Wisconsin, and Prestress Engineering Corporation (PEC) in north central Illinois.

1.2.2.1. District 1 Bureau of Materials, 201 West Center Court, Schaumburg, Illinois, 60196, April 16, 2009

A meeting was held with District 1 Bureau of Materials personnel Messrs. Kirchler, Dahhan, Tung, and Williams. Based on the discussion, input for potential enhancements to QA in Illinois from District 1 upper management follow:

- Desires more engagement of efforts with Construction.
- Recommends decreasing cement, Performance Graded (PG) binder, fly ash, and paint sampling unless reporting can be quicker and action is enforced on test failures.
    - In 2008, out of 63 PG samples, 6 failed.
    - In 2009, out of 106 PG samples, 6 failed.
- Stated they are unable to 'decertify' an inspector / tester.
- Desires to reduce time at manufacturing facilities by recognizing that component parts are typically from certified sources (cement, aggregate, liquid asphalt) and that changing the acceptance is a way to be smarter with less staff.
- Recommends asphalt mix designs to be primarily paper review with a few items checked such as Tensile Strength Ratio.
- Acknowledged their commitment to Pay for Performance, which they feel will reduce their time at the quarries, plants, and field.
- Recommends AASHTO Materials Research Laboratory (AMRL) laboratory inspection for contractors to get IDOT out of the business of performing laboratory inspections.
- Suggests refresher classes and Workmanship for Construction for the sake of industry standardization and overall improved quality of craftsmanship.
- Expressed concerns over the scarcity of high-end Materials Managers available from the consulting industry due to the accelerated construction program.
- Recommends that quality frequency be based on source history, not one policy for all.
- Believes that the number of failures to shut-down is high for aggregate sources. For example, Normal Production and Stockpile flow charts are shown side by side in figure 11 and figure 12.

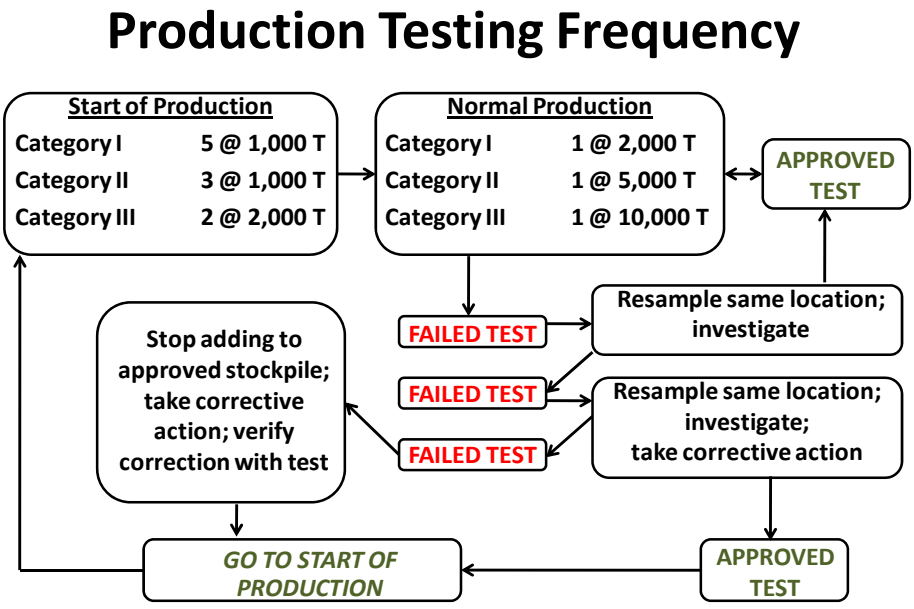


Figure 10. Production testing frequency flow chart (adapted from Beshears, et. al., 2009).

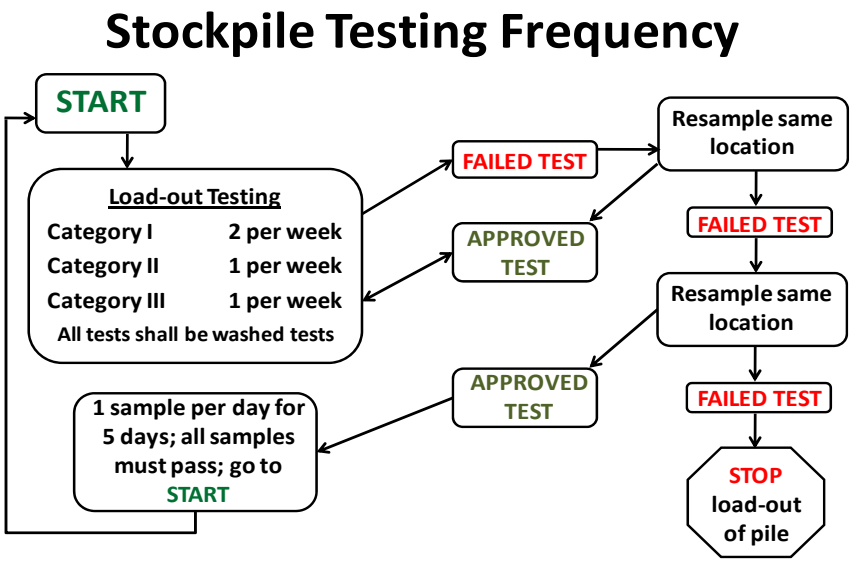


Figure 11. Stockpile testing frequency flow chart (adapted from Beshears, et. al., 2009).

The amount of materials supplied from within and to District 1, the current QC / QA requirements, and the density of projects, personnel, and contractors lends to an opportunity for reducing Department risk by increasing industry risk. One item of assurance not generally handled by other state agencies to the degree that IDOT has historically done is the inspecting, sampling, and testing aggregate gradations at quarries, gravel pits, or other production facilities. For high-end materials, HMA and Portland Cement Concrete (PCC), the Quality Control / Quality Assurance (QC / QA) program require incoming gradations by the contractor.
As shown in figure 11, it takes three failures at the aggregate production facility to force a halt in production, which is paradoxical because out of tolerance aggregate will have already made its way to the end users. Ultimately, IDOT should inspect, sample, test, and accept HMA and PCC on the grade (jobsite) at its final resting point; on the grade, behind the paver. This should be pursued for savings in manpower in addition to the improved pavement quality. This is what was mentioned by several states during the Peer Exchange and was found during the state specification review phase. This method of acceptance complies with the Code of Federal Regulations and was one of the themes of the Peer Exchange meeting.

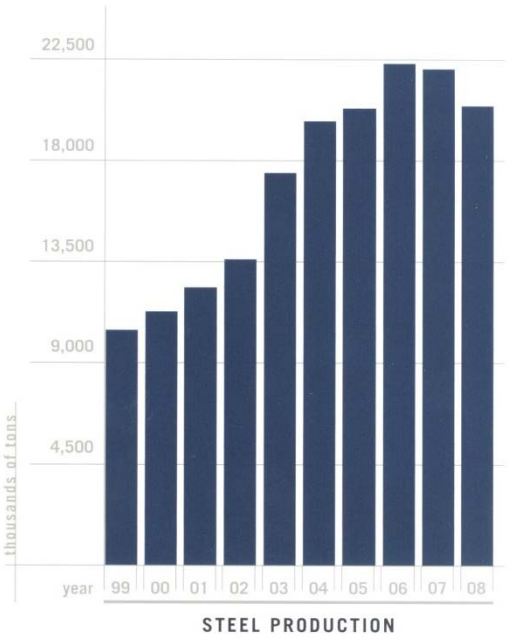
Addressing District 1 concerns specific to liquid asphalt (Total Quality Management [TQM] finding of 1996 recommended reduction in sampling) is in conflict with national norms with regards to sampling and testing; however, their concern about sampling, testing, and reporting a failure, but having no recourse to penalties or other solutions, is quite justifiable when it comes to timeliness and cost-effectiveness.

From conversations with both District 1 and BMPR, it is clear that sampling and testing of geo-textiles and geo-synthetics is overloading the BMPR laboratory because Phase III consultants are not calling before sampling and requesting testing. As Ed Hughes stated, “They sample it and send it to us so we test it as that is our commitment to supporting the districts.” The breakdown in communication on this one item is significant, especially when considering the time and cost to inspect, sample, and test such a low-risk product multiple times that generally passes strength tests. Managing the system and educating Resident Engineers / Technicians must continue to occur on low to high risk materials with the value of a test being taken into account for the risk of the product. Sometimes this means that the BMPR should not perform a test requested based on the facts that they know specific to a particular product.

1.2.2.2. District 3, Nucor Steel Kankakee, Inc., 972 East 4500 North Road, Bourbonnais, Illinois, 60914-4127, June 11, 2009

The Quality Control discussion and plant tour was given by Mr. Curtis Glenn, Metallurgist / Safety / Quality / Production Specialist of Nucor, Bourbonnais.

According to the *Nucor 2008 Annual Report*, in 2008, Nucor had net sales in excess of $23.6B with an EBIT of approximately $2.8B. Nucor, Bourbonnais (one of 50 Nucor locations) produces more than 95% of the reinforcement bars for Illinois projects. The plant consumes $1M of electricity each month processing 60,000 tons of scrap with 85% yield. This adds up to approximately 800,000 tons of scrap per year. Nucor management realizes that they are paid on quality product out the door.



Nucor's stated corporate goal is to:

> *'Take care of our customers.' We are accomplishing this by being the safest, highest quality, lowest cost, most productive and most profitable steel and steel products company in the world. We are committed to doing this while being cultural and environmental stewards in our communities where we live and work. We are succeeding by working together.*

To ensure quality control, Nucor, Bourbonnais staff checks loads of incoming steel visually and maintain a constant camera on their property to eliminate renegade dumping. Nucor only uses approved scrappers as they are harvesting the existing infrastructure for tomorrow's construction projects. They produce steel in 85-ton heat sizes.

Nucor is ISO 9000 and ISO 14000 accredited. One example of their QC System is that for 60ksi steel, they have a warning limit of 63 ksi and a stop action at 61 ksi test results. Nucor would support NTPEP and a few audits per year in place of the numerous individual audits by agencies that they currently require because they supply materials to New York, Kansas, Missouri, Texas, Louisiana, Indiana, Pennsylvania, Iowa, Nebraska, and South Carolina in addition to Illinois.

Historically, IDOT failures on bend tests of epoxy coated reinforcement bars that were produced at Nucor and then epoxy coated by others led IDOT to adopt A706 versus A615 steel for use on IDOT projects.

Ambassador Steel applies the epoxy coating and does fabrication work. There is ongoing Quality Control at Ambassador to check coatings for pin holes, cracks, abrasions, holidays, and coating thickness. Ambassador Steel is a brand new facility, the largest in the United States, with the ability to coat 12 bars at a time. CRSI audits Ambassador Steel in addition to IDOT and other State agencies. Several states around the nation do not check coating thickness but instead accept product on certificates of compliance.

The large tonnage and supply stream combined with the structural nature, and therefore high risk use, from these two plants to projects within Illinois has led IDOT to inspect, sample, and test product on an on-going basis. Recent QC and QA inspection, sample, and test results should be used to guide future sampling and testing frequencies by IDOT.

1.2.2.3. District 3, Prestress Engineering Corporation (PEC) Plant, IL17 between Dwight and Streator, Illinois, July 6, 2009

Figure 12. Damaged PPC I beam (Murphy, 2009).

Figure 13. Concrete cylinders curing (Murphy, 2009).

Approximately 15 years ago, IDOT personnel did everything required per the Method Specification of the era for precast prestressed concrete (PPC) products. An IDOT task force was formed because industry QC was deficient. IDOT, with input from industry representatives, wrote a program for industry to follow. The goal was to eliminate low breaks, out of specification air, and uncontrolled temperatures during concrete pours and to give "ownership" of product being manufactured back to the producer. Prestressed Concrete Institute (PCI) Level I and II and ACI are requirements for QC. Digital cameras are used to document when QA is not present, which is a good use of modern technology by PEC.

Opportunities exist to require larger minimum concrete batch size, to require QC Manager 24 / 7 based on production schedules, and a paved yard to reduce sloppy yard conditions. Several rejected beams were reviewed during the tour.

District 3 recently hired a consultant to handle QA for PEC, but system oversight is still handled by the Department. They observe 75% of tensioning and perform nearly 100% post-pour QA. If there are deficiencies that the owner (IDOT Construction or Local Agency) accepts, then credits are handled on the construction project.

1.2.2.4. Idaho Transportation Department, 3293 Jordan Street, Boise, Idaho, 83707, April 21, 2009

A review of QA documents and an interview with Mr. Muhammad Zubery, QA Engineer at the Idaho Transportation Department (ITD) yielded the following findings:

- Failing steel is rejected.
- No sharing of information between states.
- Currently testing geo-textiles; however, ITD is looking to reduce or eliminate testing of geo-textiles based on limited risk.
- Liquid AC is a three person lab. ITD takes daily binder samples, job specific, and one per week is tested by Boise Lab. There is a price reduction schedule based on nonconforming tests. Dispute resolution is handled by Petroleum Sciences for ITD and industry.
- Cement / Fly Ash require physical testing by lab. Construction Technologies Lab in Skokie, IL, is the dispute laboratory.
- The specification and QA committee decides tests, frequencies, and the reasonableness to placing a product on the qualified products list on an on-going basis.
- Since FHWA non-participation drives ITD, penalties exist for non-conforming material.
- Reinforcement steel is sampled and tested every size and heat for pull and bend. No epoxy coating thickness checks are performed.
- Dowel bars (A254) are accepted with certificates of compliance per heat.
- Bolts, nuts, and washers are accepted with certificate of compliance.
- Structural steel is handled by consultant, other state agency, or Utah DOT.

- PPC is handled regionally with Washington, Oregon, and Idaho having 7 plants, and 100% inspection is performed. PCI is required for QC Managers.
- Concrete producers must follow National Ready Mix Association (NRMA) or Portland Cement Association (PCA) for plant certification and QC.
- HMA assurance is handled in-house by ITD at this time. This is a Pay Within Limits State for HMA based on Volumetrics and in-place density.
- ASR laboratories must be CCRL accredited.

1.2.2.5. Private Industry, Geo-Synthetics, Inc., 2401 Pewaukee Road, Waukesha, Wisconsin, 53188, May 23, 2009

On a site visit to Geo-Synthetics, Inc. in Wisconsin, owners Messrs. Robert F. and Michael Groh provided the following information and observations:

- Geo-Synthetics Research Institute (GRI) hired Drexel University to perform a nationwide study on producers and determined consistency existed between suppliers (competitors) in quality.
- Credit should be offered in lieu of removal and replacement for non-compliant product; base credit on the criticality of end use.
- Develop material strength specification, not a unit weight based one. Use new technology for evaluating product and performing risk analysis.

1.2.2.6. Private Industry, Hamilton-Sundstrand a United Technologies Corporation, Rockford, Illinois, May 24, 2009

The majority of the conversation with Mr. Santiago Lopez, Hamilton Sundstrand (HS) Quality Manager, centered on first article sampling and testing, system audits, and staffing. HS has practiced inspecting in quality since the 1950s. HS has embraced Quality Management Systems practices, adheres to ISO 9001 and ISO 9100, and currently works under the Achieving Competitive Excellence (ACE) operating system. At HS, all vendors and HS employees are treated the same way.

A lab sample is submitted with a materials analysis certificate of compliance prior to it being considered for use at HS. (NTPEP can play this role for IDOT.) Once the product passes first article testing, it is closely monitored for two years prior to being added to the Qualified Product List (QPL) and HS maintains a Supplier Rating List that statistically measures consistency and compliance, is performance driven, and requires interrogations on non-compliance.

Ongoing, HS will coupon sample randomly for various materials used in the construction of parts. There are multiple tiers of auditing, such as first party inspection, oversight (systems effectiveness group), third party (outside agency), customers and the Defense Contracting Management Association. The accumulation of these efforts makes up the HS Product Quality Assurance (PQA) System.

If a non-conformance is found; 85% of the time it is a Go As Is, 15% of the time it is Reworkable. The approach is Level One, Level Two, and Level Three (outlined in Appendix 3). Approximately 5% of non-conforming parts require judgments to be made by a committee called the Material Review Board (MRB). The MRB looks at cost, criticality of product, total unit delivery, and options.

In all cases HS tracks:

1. Root Cause,
2. Remediation,
3. Containment and Communication,
4. Corrective Action.

Quality Assurance is handled internally as often as possible; however, when HS outsources, it is only to an organization that works for them, not for an organization that works for their vendors. (This stands in stark contrast to the problematic scenario outlined in the preface of this report; see Alonso-Zaldivar's article, "Private Inspections of Food Companies Seen As Weak", 2009.)

1.2.2.7. Private Industry, Andee Boiler & Welding Company, Chicago, Illinois, Various, 2009

Discussions with the Engineering Administrator, Mr. Jeffrrey J. Murphy. Mr. J. Murphy has an intimate working knowledge of ASME and the boiler company requirements for engineering calculations, materials purchase (domestic steel act) and control (heat numbers), as well as shop and field quality control. Each step is handled by the use of a traveler, the working document that exists from material purchase through quality assurance acceptance, for constructing pressure vessels. ASME performs random audits of organizations throughout the nation, holds formal meetings and inspections every 3 years at each manufacturer's plant, and requires that all files be kept for a period of 5 years. As a contractor who manufactures and repairs pressure vessels, Mr. J. Murphy actively and openly participates in the best practices recommended by ASME. This auditing system is supported by annual fees to participate, fees to register vessels built and worked on, and annual sales of standards manuals. This ASME quality system has worked well on a national basis for several decades. IDOT should consider making AMRL and other national assurance programs part of all material suppliers Quality System, for all products across all lines.

1.2.3 Findings of Office Visits

Each of the visits detailed above involved different engineers in varying roles within the material use process, whether it was an owner (IDOT), manufacturer, or end user who purchases products from manufacturers and sells to owners, presenting different cases for the same case. Summarily, why inspect, sample, and test materials that pass nearly 100% of the time and have low risk without inspecting, sampling, and testing high-risk materials that do not approach a 100% passing rate? We must work with vendors to produce high quality product as near to 100% of the time as possible. QC efforts need to be driven by standards and industry ability. At General Electric, according to the company's 1996 annual report, "It has been estimated that less than Six Sigma [standard deviations], a quality model for businesses, i.e., the three-to-four Sigma levels that are average for most U.S. companies, can cost a company as much as 10-15% of its revenues." For GE, that would mean a loss of $8-12 billion. Industry needs support by State agencies to help define, measure, analyze, improve, and control processes, and the agency must continue to perform a random acceptance program to ensure accountability and quality.

If an inferior product is used, then credit should be given to the client. In situations where the contractor (manufacturer) supplies IDOT non-compliant product, then IDOT should pay less than 100% if the product is left in place, typically per a step pay schedule (ref. figure 6). This style of acceptance and payment however it or a more sophisticated process should be implemented across all material products consumed by IDOT (Illinois Special Provision: "Pay for Performance for Hot Mix Asphalt").

A questionnaire should be sent out to all levels of IDOT throughout the state asking, "What can we change based on risk and history?" IDOT should emphasize making decisions based on safety, performance, and historical test measures. When an organization uses statistics to make decisions, they can avoid making inappropriate, ill-timed, or costly knee-jerk reactions to small, random changes in outcome. Statistics allow decision makers to differentiate between chance occurrences and systematic factors that significantly affect product or service quality. The distribution and analysis of such a questionnaire will not be a simple task, and it will require updating to meet the needs of the industry on an ongoing basis, but this should be considered the first action item as IDOT moves forward to a safer, more cost-effective future.

1.3 TASK 3: GATHER INFORMATION

The priority for task 3 was to gather information on the practices of other States nationwide. The goals were to develop a questionnaire specific to state quality assurance programs, following up with costs to perform a test, manpower studies, and to determine how other states handle non-compliant materials. An added finding was National Transportation Product Evaluation Program (NTPEP) and how this organization might help IDOT meet assurance goals.

1.3.1 Questionnaire Development

In consultation with IDOT staff, part of the proposed work for task 3 included the development and distribution of a survey to key states with similar programs and needs was developed. The full text of the computer-based questionnaire that will identify DOT testing, evaluation practices, and procedures is available in Appendix 4. Based on information gleaned from the distribution of this survey, it would be possible to identify key state DOTs with testing, evaluation practices, and procedures that could prove beneficial to IDOT. Follow-up action could be taken to provide more in-depth knowledge of the testing and laboratory operations of these key states.

Extensive written and verbal follow-up interviews would allow for an adequate understanding of the various laboratory testing units and facilities available in other states from around the nation. A more detailed and comprehensive second survey would allow IDOT to identify new, improved, or unique alternatives that may be beneficially implemented for future use by providing useful comparisons between IDOT and key state laboratories, staffing levels, and the extent of testing, evaluation practices, and procedures believed necessary for materials and construction quality elsewhere. IDOT staff met with the principal investigator to develop a list of items and questions to be covered in the key state questionnaire. Ultimately, to focus on procedural review and attend to the Peer Exchange, the Department chose not to distribute this questionnaire nationwide at this time.

1.3.2 Procedural Review

State QA Procedures that were reviewed by the investigators prior to the QA Peer Exchange included the following:

- *Illinois Department of Transportation (IDOT)*
  - *Standard Specifications for Road and Bridge Construction*
  - *Materials Project Procedures Guide*
  - *Materials Inspection Manual*
  - *Construction Manual*
  - *MISTIC Materials List*
  - *MISTIC Producers List*
  - *PPC Fabrication Manual 2009*
  - *Approved Alkyla Silica Reactive (ASR) Labs*
  - *Approved Materials List*
  - *Bureau of Materials and Physical Research Materials Specifications*
  - *Bureau of Materials and Physical Research Policy Memos*
  - *Bar Splicer Coupler Guide*
  - *Fastener Identification Guide*
  - *Rebar Guide*
- *Idaho Transportation Department*
  - *Materials Manual*
  - *Quality Assurance Manual*
- *Indiana Department of Transportation Materials Manual*
- *Iowa Department of Transportation Materials Manual*
- *Kentucky Department of Transportation Materials Manual*
- *Michigan Department of Transportation*

    - *Materials Quality Assurance Procedures Manual*
    - *Manuals for Michigan Test Methods*
    - *Material Source Guide Complete*
- *Missouri Department of Transportation Materials Manual*
- *Wisconsin Department of Transportation Materials Manual*

All states reviewed have well-defined QA Systems in place—such as QC, Verification Sampling and Testing, and Independent Assurance—and all appear to meet the FHWA Code of Federal Regulations (CFR) for acceptance of products. Most states are similar to IDOT in defining Quality Systems for Material Manufacturing, Tests, Approved Producer / Supplier Lists, Approved Laboratories, Qualification Training, Plant Reports, Mill Test Reports, Manufacturer's Certification, and Resident Letter of Visual Inspection. Most states have developed levels of inspection, sampling, and testing based on the criticality of the item being manufactured, quantity or material being used, and ability to test with 'on hand' equipment in the state laboratories.

1.3.3 Payment Schedules

One substantial action item for consideration by IDOT was recognized from the review of other states (excluding a detailed discussion on HMA and PCC) is that several states have instituted payment schedules for various products for non-conformance. For example, the magnitude of the price adjustment in Wisconsin, Kentucky, and Idaho, expressed as a percentage, are based on the extent of the deviation from the specifications as determined by test results. The determined price adjustment percentage will be applied to the quantity of the materials that is represented by the non-compliant test results. Items that are typically included are:

- Portland Cement
- Fly Ash
- Water-borne traffic line paint
- Coating Systems
- Liquid Deicers
- Performance Graded (PG) Asphalt Binders
- Emulsified Asphalt
- Geotextiles.

In using the SCA procedure, it is helpful to have some knowledge of the overall variability inherent in the highway construction processes, the variability inherent in the natural makeup of materials, the variability associated with sampling and testing, and the effect these variabilities have on performance. Through substantial research, validation of in-service performance, and defining expected levels of manufacturing competency, these states now have well-defined acceptance, rejection, and payment deductions limits. A complete list of specific equations for deductions is shown in the Material Acceptance Methods State Comparison Wrap-up Post Peer Exchange file located in Appendix 5; however, some major pay items include:

- PG Binder – 10% to 50% reduction based on variations in characteristics listed on page 806-1 of the Standard Specifications.
- Aggregates – Up to a 50% reduction based on invoice prices if the product is out of specification on more than one sieve.
- Pavement Marking Paint – 10% reduction for color, 60% reduction for heavy metals, 10% reduction for TiO_2, 60% reduction for VOC, and 10% reduction for contrast out of specification required ranges.
- Reinforcing Bars:

    - Yield Strength - 20% to 50% reduction for a 96% to 86% of required yield strength by specification.
    - Tensile Strength - 20% to 50% reduction for a 96% to 86% of required yield strength by specification.
    - Elongation - 20% to 50% reduction for a 96% to 86% of required yield strength by specification.
    - Weight per foot - 20% to 50% reduction for a 93% to 86% of required yield strength by specification.
    - Epoxy Coating Thickness - 25% reduction for epoxy coating of 14-15 mils in thickness.
- Structural Steel Coatings – 20% reduction for density, 30% reduction for weight solids, volume solids, pigment, and metallic pigment content 10% reduction for volatile organic compounds, as well as color and color differential outside of specification requirements.
- Concrete
    - Slump - 2% to 50 % reduction for a 0.25" to 2" variance in slump.
    - Air content - 5% to 50 % reduction for a 0.1% above spec to 1.0% below specification requirements.
    - Temperature - 25 % reduction for any overages.
    - Time limit - 25% reduction for any concrete used over the time limit.

Opportunities similar to those listed above exist for BMPR consideration. Specifically, during the QA Peer Exchange, it was recognized that IDOT was not sampling and testing PG Binder at a frequency of the visiting states. For 2010, IDOT has increased their inspection, sampling, and testing of PG Binders at the HMA facility; however, they have yet to institute a penalty structure similar to that shown above and instituted by many surrounding states. It should be noted that IDOT has begun to roll out a system of competency for HMA producers with the development of a Pay for Performance (PFP) (also known as Pay Within Limits [PWL]) specification. This specification was exclusively left out of this research project, as IDOT was handling the development and implementation in-house during this time period.

1.3.4 National Transportation Product Evaluation Program (NTPEP)

Another important item found during research and further discussed on phone interviews with QA Peer Exchange state representatives is that, over time, the hold point for many material manufacturers is with obtaining the approved source stamp of approval (First Article) by the state agency they wish to work for in supplying their product. This is a global concern; to promote regional and national approval of new sources, IDOT should embrace and work with outside organizations, such as AASHTO's National Transportation Product Evaluation Program (NTPEP) and the MCC, to better work with industry in resolving this time-consuming and inefficient process. To this end, Mr. Lippert, BMPR Bureau Chief recommended a review of NTPEP

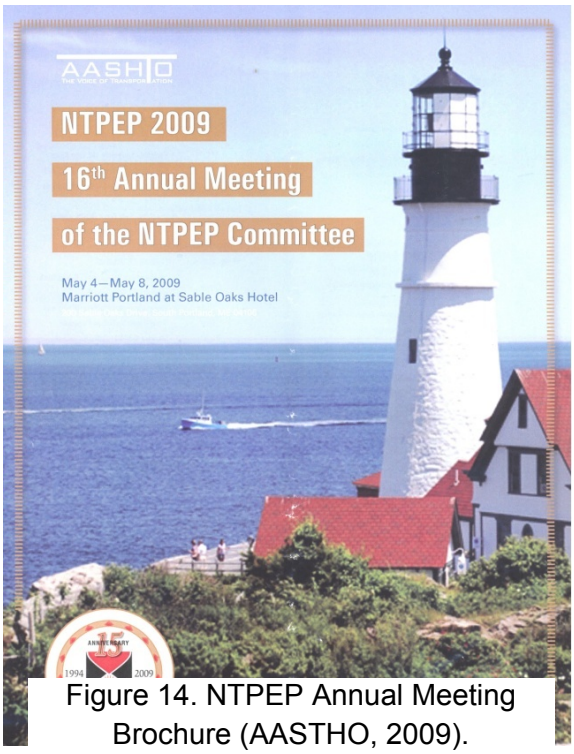


Figure 14. NTPEP Annual Meeting Brochure (AASTHO, 2009).

NTPEP is in a place to assist in building a QPL, not to supplement or replace QA sampling and testing. NTPEP handles first article inspection, sampling, and testing which requires formalized standards, initial on-site inspection, quality manual review and approval, sample testing, and report of findings. Items covered by NTPEP and discussed at their annual meeting include items in the area of traffic safety, construction, maintenance, and data-mining and are included in Appendix 6. Throughout the meeting it was mentioned that NTPEP recommends that the quality system manuals of manufacturers should follow the format of AASHTO R-18 to ensure the highest material and product manufacturing compliance. This program is similar in nature and desired outcome to the American Society of Mechanical Engineers (ASME) program for pressure vessels.

NTPEP is capable of providing auditing services. According to their web-site (www.ntpep.org) and brochures, NTPEP partners with technical experts, industry, and industry associations to develop quality and responsive engineering for the testing and evaluation of products, materials, and devices commonly used by DOTs. Items under their scrutiny / purview include highway safety products, geotextiles and geosynthetics, erosion control products, structural steel coating systems, and other transportation construction materials. NTPEP maintains an active dialogue with industry leaders and DOT representatives through annual meetings.

NTPEP strives to serve the public interest through proactive communication, encouraging product innovation, and a commitment to public responsibility. By developing and evaluating products in the laboratory and in the field (with required re-testing every 5 years to remain on the NTPEP Qualified Products List), and by reporting their data and findings in a timely manner, NTPEP works to enable cooperative partnerships that allow transportation decision makers to become informed consumers.

During research, the opportunity arose for Messrs. Mueller and Murphy to attend an annual NTPEP meeting in May 2009 in Portland, Maine. This event, along with the recent follow-up meeting in Illinois, impressed the fact that there is an opportunity to hand off the qualification and maintenance of qualification of vendors to NTPEP, limited to NTPEP area of expertise. The underlying theme that NTPEP does not provide QA was sounded numerous times by agency attendees, but their hard copy published documents contradict that statement; this must be revised. If their intent is to supplement a QA program by providing initial and annual manufacturing facility review, then IDOT could adopt that approach where it is beneficial to Illinois. With regards to acceptance of product, there will need to be a 'wait and see'

approach as NTPEP evolves in specific areas.

NTPEP visited Illinois in September 2009, and the full agenda and list of participants from this meeting can be found in Appendix 7. NTPEP seemed to learn as much as, if not more than, what they brought. Because of the high-quality engagement between NTPEP and IDOT, it is recommended that IDOT strongly consider becoming a more active voice with NTPEP, to collaborate and share success stories with a broader audience, to help guide this national organization, and to benefit from meeting with other experts on an ongoing basis. IDOT has much to offer NTPEP in the areas of aggregates, HMA, cements, metals, and chemicals based on the expertise of the Section Heads. To this end, it is recommended that IDOT representatives regularly attend the national meeting and participate actively in sub-committee meetings throughout the year.

NTPEP is less costly than the Concrete Reinforcing Steel Institute (CRSI); the manufacturers fee for having their quality system audited and first article inspected, sampled, and tested by NTPEP is $7,500.00, while the cost of CRSI is $12,000.00 plus a fee on each pound of bar sold. Manufacturers are concerned with this high cost however IDOT, as well as other states, should take the position that this is now a cost of doing business in the United States. Plainly stated, it is a user fee.

PHASE 2 MULTI-STATE PEER EXCHANGE & MATERIALS TESTING WORKSHOP

Phase 2 used the information gathered in Phase 1 to organize and conduct a Multi-State Peer Exchange and Materials Testing Workshop with representatives from four states with practices that could potentially benefit IDOT. The Multi-State Peer Exchange and Materials Testing Workshop was organized and held in October 19-21, 2009, in Springfield, Illinois.

2.1 ATTENDEES

Mr. Alan Rawson of the New Hampshire DOT, Mr. Jeff Seiders of the Texas DOT, Mr. William Stalcup of the Missouri DOT, Mr. Ronald Walker of the Indian DOT, and representatives from BMPR and FHWA were in attendance at the Multi-State Peer Exchange and Materials Testing Workshop. The carefully selected attendees maximized discussion and interaction between participants regarding specific subject matter. See Table 1 for a detailed list of the Visiting State and FHWA Peer Exchange experts. See Appendix 8 for a complete list of attendees and their contact information.

Table 1. List of Multi-State Peer Exchange & Materials Testing Workshop Visiting Attendees.

Name & Organization Address	Telephone	E-mail
Alan Rawson, P.E. New Hampshire DOT Bureau of Materials and Research 5 Hazen Drive PO Box 483 Concord, NH 03302-0483	(603) 271-3151	arawson@dot.state.nh.us
J. Jeff Seiders, Jr. P.E.* Texas DOT Construction Division M & P 125 East 11th Street, CP#51 Austin, TX 78701	(512) 506-5808	jseider@dot.state.tx.us *Attended via teleconferencing
William Stalcup, P.E. Missouri DOT Materials Division 1617 Missouri Boulevard P.O. Box 270 Jefferson City, MO 65109	(573) 751-1036	William.Stalcup@modot.mo.gov
Ronald Walker, P.E. Indiana DOT Office of Materials Management 120 South Shortridge Road Indianapolis, IN 46219-0389	(317) 610-7251 x 204	RWalker@indot.in.gov
Hal Wakefield, P.E. Federal Highway Adminstration 3250 Executive Park Dr. Springfield, IL 62703	(217) 492-4646	hal.wakefield@fhwa.dot.gov

Prior to publishing an agenda, BMPR, FHWA, and MPT developed a survey that would potentially be used as a nationwide survey. After discussion with BMPR upper management, it

was decided to use the survey as a launch point for conversation throughout the QA Peer Exchange.

The QA Peer Exchange Materials Testing Workshop agenda, found in Appendix 9, was decided with IDOT staff input based on needs and priorities. Mr. Murphy developed speaking points for invited states with IDOT participants and facilitated the meeting. After an exhaustive state survey of acceptance programs, Illinois meetings and summaries of findings to date, and with BMPR input, it was decided to involve representatives from a small and large state as well as neighboring states. The State Quality Assurance Procedures discussed during Quality Assurance Peer Exchange included those of the following states:

- Texas
- New Hampshire
- Indiana
- Illinois
- Missouri

2.2 TOPICS FOR DISCUSSION

The invitation sent to the agencies attending, titled Peer Exchange Points of Interest, was open-ended but seeded with current potential hot topics. The text of the invitation follows:

> Over the past several years, the Illinois Department of Transportation (IDOT) has experienced severe cutbacks in staffing. We have recently conducted several streamlining efforts to reflect our workforce reduction of over 40 percent. As we go forward, we wish to draw upon the experience of others who face similar streamlining challenges. To assist in this effort, please review the following points we would like to discuss during the exchange. You may wish to address these in your presentation or in our discussions.
>
> **Source Material Laboratory Testing Programs**
> Aggregate, Asphalt, Cement, Metals, (rebar, structural steel and fasteners), Paint and other miscellaneous materials:
>
> - Describe the quality program (certification, batch / lot test and approval by state or third party results), and roles of the state, producer and those receiving product.
> - Please indicate type of testing performed, frequency and if results are used for ranking / accepting material or informational.
> - What roles, if any, do consultants play in the process to assist the state?
>
> **Manufactured Material Programs**
> HMA, Concrete, Precast Concrete Products and Prestressed Structural elements:
>
> - Describe the quality program (QC / QA), and roles of the state and contractor / supplier. Please indicate frequency, type of testing performed and if results are used for accepting material or informational.
> - What roles if any do consultants play in the process to assist the state?
> - If incentive / disincentive pay adjustments are made, please describe the pay factors, role of contractor information and owner controls on custody of materials for testing.
> - Training programs – are contractors required to have a level of training (state or national program) to supply material?

Miscellaneous Issues

- How has NTPEP been used in your state?
- AASHTO Site Manager or other in state material test database system:
- The good, bad and ugly of your system.
- How are you supported by your state IT staff?
- How user friendly, problems, ability to flow construction information in and out?

The items listed above, as well as responses to the invitation, were incorporated into their presentations and discussions during the Peer Exchange Meeting, allowing for the fruitful sharing of information amongst federal and DOT representatives.

2.3 QA PEER EXCHANGE PRESENTATIONS

Mr. David Lippert welcomed the group and gave his update on the status of the BMPR employees, abilities, and responsibilities. As of 2009, BMPR was 40 people below 1992 staffing levels, so outsourcing is continuing to maintain best possible level of service possible. Mr. Lippert noted that more items are going to certification procedures which may increase the risk to the IDOT. Due to the loss of staff, there is a longer turn-around for test results and therefore BMPR is a hold point for job progress; this unacceptable delay is an unfortunate necessity to avoid the increased risk that comes from not performing acceptance.

Some relief is in the works as BMPR is expected to hire up to 12 new employees in 2009 and 2010; however, these will be new and possibly inexperienced employees. Based on the

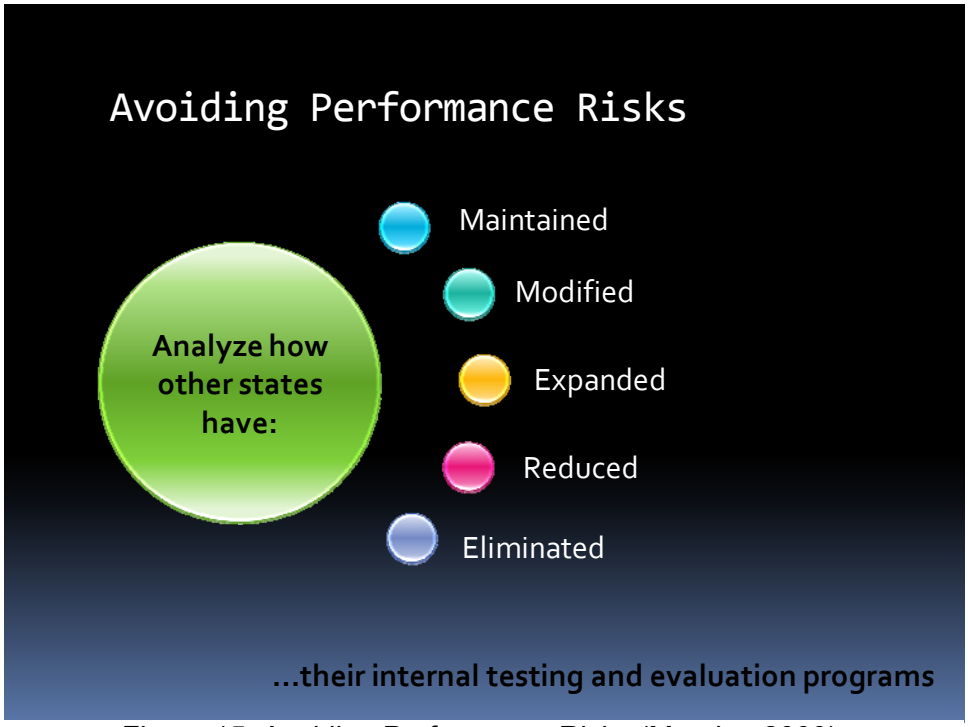


Figure 15. Avoiding Performance Risks (Murphy, 2009).

past and the future, IDOT BMPR is committed to redefining roles and responsibilities as well as taking a fresh look at what is most productive and where to make positive changes specific to acceptance. BMPR wants to be able to re-staff for research to complement what the Illinois Center for Transportation is capable of performing through their agreement with IDOT. Summarily, IDOT wants to 'right size.'

2.4 SIMILARITIES, DIFFERENCES, AND CONCERNS DISCUSSED

IDOT representatives determined their areas of need and questions of concern to discuss at the Peer Exchange. These issues, coupled with information garnered from a review of the literature, State responses to the initial invitation, informal conversations, and a kick-off meeting, led to the development of an agenda. Ultimately, presentations and discussions covered a useful overview of similarities and differences between state DOTs. Each state representative learned new or modified techniques and practices from the others, offered key observations on the practices of other states, noted common and unique areas of challenges, and encouraged positive approaches to problem-solving. This occasion of cooperation and collaboration afforded IDOT the valuable opportunity to share with and learn from other states. It is recommended that Peer Exchanges become a frequent fixture of IDOT operations.

2.4.1 Illinois Department of Transportation Needs Statements

The BMPR Section Heads presented needs statements to open dialogue with the QA Peer Exchange participants. The key items brought up by each Section Head included the following:

- S. Beshears – *Research*: Multiple test methods exist to determine aggregate specific gravity values; what is working for you? Additionally, IDOT reported their findings to date with the Micro Duval for aggregates and RAP as it appears to be possible to replace soundness and abrasion; however, more resources are required to validate this hypothesis in a timely fashion.
- J. Trepanier – *History and the Future*: QC / QA since 1991, PFP from 2009 forward, training agreement with Lake Land College. Obtained a collective agreement from the Peer Exchange participants regarding the merits to behind the paver sampling for HMA, as most present believe that it measures quality most accurately.
- D. Dirks – *Cement*; discussed sampling frequency and how we can capture data from work done by other agencies from the same source. Missouri will work with Dirks on this issue.
- E. Hughes – *Foreign Steel*; do you educate construction personnel to ensure compliance? Most in attendance found his discussion a viable topic to take home to their States. Plastic Pipe; are you visiting production facilities and are you testing? IDOT will continue to visit production facilities; Hughes gave an example of plastic pipe testing in the laboratory.
- V. Prill – *Chemical testing* of products is of ongoing importance to IDOT, especially for bridge paints, crack sealant, and pavement markings however this unit is interested in knowing what is done around the nation. Major finding from presentation is that all PG failures that occurred were from samples taken at HMA facility, not liquid facility (see figure 18.) IDOT should encourage training between liquid suppliers and HMA facility owners, continue random acceptance, and consider payment deduction protocol. Newer equipment helps IDOT with chemical analysis in the Instrument Laboratory.

Figure 16. Hughes discussing testing of pipe (Murphy, 2009).

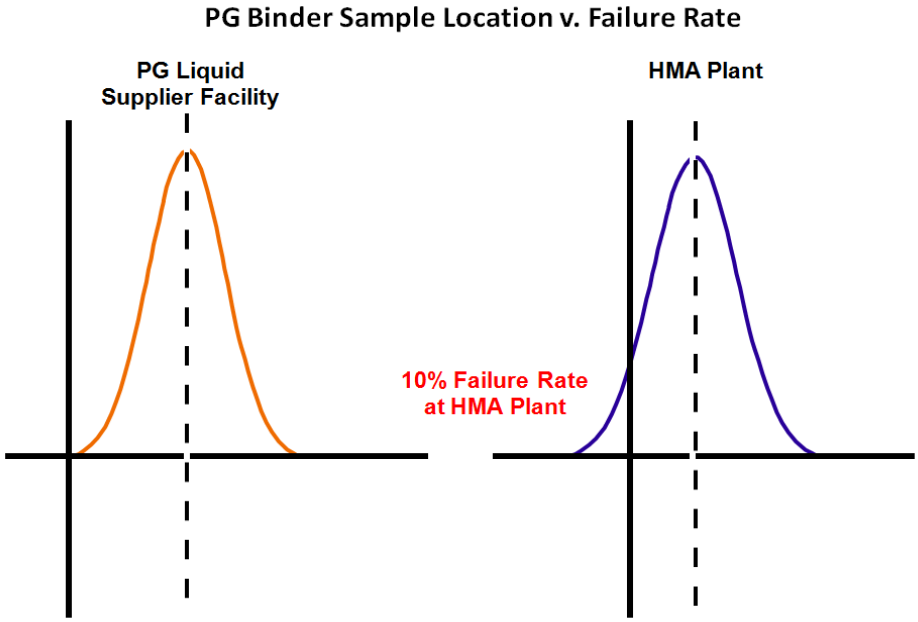


Figure 17. PG binder sample versus failure rate, showing the consistent success of a PG liquid supplier facility and the typical 10% failure rate at an HMA plant (Murphyao, 2010).

2.4.2 Similarities and Differences

Peer Exchange participants liked that IDOT was asking about practices underway elsewhere and finding out about success rates. Furthermore, they appreciated that IDOT has inspection guides available to materials and construction personnel and that IDOT continues to hire and train staff (both internal and for contractors) in this current economic climate. Presentations were made by the following state DOT representatives:

- New Hampshire DOT – Mr. Alan Rawson
- Indiana DOT – Mr. Ron Walker
- Missouri DOT – Mr. Todd Bennett
- Texas DOT – Mr. J. Jeffrey Seibert (via webinar)

The materials acceptance programs discussed shared several similarities to IDOT's approach, but differed in others. Most states that visited are pro-NTPEP, AISC, PCI, CRSI, NEPCOAT, ACI, AASHTO, and AMRL for many materials and processes to obtain acceptance, with some similarities to and differences from IDOT. The New England states have an agreement (the Northeast Transportation Technician Certification Program [NETTCP]) to manage and deliver the certification training program for HMA, PCC, AC, and soils throughout all of the NE States.

After each state presented information about their assurance system and its current operations and functioning, the group took time to summarize the key items shared, talk about differences and potential alliances that could be developed, discuss opportunities and challenges, and develop a list of action items for the future. Several participants e-mailed in their take-away list from the Peer Exchange, and the full text of these e-mails are available in Appendix 10.

Key items shared by the visiting states that differ substantially from IDOT's practices included:

Acceptance Practices:

- Pay schedules for non-conforming materials left in place. (IN)
- Acceptance of quality only at quarries and pits, not gradations. (IN)
- HDPEP and PVC pipe are NTPEP and certification accepted not tested. (NH).
- Uses NTPEP for HPDE pipe to eliminate some in-house testing. (IN)
- Concrete and steel pipe are certification accepted. (NH)
- Reinforcement steel is NTPEP and certification accepted not tested (TX and NH, starting in 2010).
- Uses torture test for HMA; Hamburg Wheel. (TX)
- Inspects, samples, and tests PG asphalt at higher frequencies with pay adjustments for non-compliant product. (IN, MO, NH, TX).

Skill Sets Building:

- Starting a superintendent training program in 2010 specific to equipment and workmanship. (IN)
- Training program for summer help / college students in lieu of attending full blown certification training. (MO)
- Recertification of inspectors. (IN, MO, TX)

Support Systems:

- Uses SiteManager. (TX, MO, IN)
- Quarterly agency meetings to share successes and address shortcomings. (Various)

2.4.3 Key Observations and Practices Discussed by States

1. MO – Blending procedures used for skid resistance. (from IL and IN)
2. MO – Aggregate quality monitoring program. (from TX)
3. IN – Staff is reducing yet program has doubled because of the lease of the Indiana toll road.
4. IN – Quantify what materials have historically provided a good quality and have lower risk. i.e. Certified Aggregate Producers Program (C.A.P.P.) from IN. (Get out of the quarry for gradation, stay in for quality.) MI using plus #16, IN doesn't allow limestone sands over 20% in surface mixes.
5. IN – Not going to contractor acceptance yet they feel comfortable that if pushed they could do it.
6. IN – Certified HMA producer program, CAPP, QC plan per project with project level details all the way through materials, machinery, and methods.
7. IN – Starting a superintendent training program in 2010 specific to equipment.
8. IN – monthly meeting with districts, great relationship with testing engineers, district representatives go to central office
9. NH – Quality management systems are good first step for manufacturers. (from TX)
10. NH – Would use certified HMA producer for local agencies using federal funds. (from IN)
11. TX – Interested in developing training program for summer help / college students in lieu of attending full blown certification training. (from MO)
12. IL – Wants a torture test for HMA; probably Hamburg Wheel. (from TX)
13. IL – Wants a comfort level with respect to friction aggregate blends. Needs the ability to capture more real data from the roadway. (only doing 250 locations / yr.) From Walker; FHWA states that they would want you to use the best material reasonably available to you.
14. IL – Renewal of training program / staff.

15. IL – PG liquid sampling daily at HMA contractor facility. IDOT sampling 2 / grade / plant / mo. Check Bill of lading (BOL).
16. IL – Checks on other steel items including fasteners, prestressing strands, and light poles in addition to rebar.
17. IL – Imposes a $5,000.00 or the payment price of the product used fine for the use of foreign steels.
18. IL – Charges manufacturers to pay for travel to perform on-site assessment.

2.4.4 Gauging Opportunities and Challenges

1. Facilities, efficiencies, safety, and morale. New technology leads to eliminating currently useful equipment based on space needs.
2. Material quality improvement through the use of updated technology (specialized equipment). Hamburg Wheel
3. Staffing needs, long term versus short term.
    a. IDOT employees, trained staff (long term solution). The needs are throughout the organizational chart, not just 'newbees'.
    b. Consultants (Short term solution)
        i. IL – Using consultants in the lab as part of your 'peak season' helpers. (Both)
        ii. IN – Doesn't use consultants. Redeploying workforce within the Bureau as well as between Districts.
        iii. TX – Using large amount of consultants.
        iv. MO – Doesn't use consultants.
        v. NH – Using consultants in materials 'as needed'.
4. On-the-job (OTJ) training versus current ability to perform as set up with Lake Land College (LLC).
5. Role & Mission – BMPR recognition and image. Maintain, sustain, and grow the ability to be the experts for all road and bridge construction components; from analysis through long term performance.
6. Pay adjustments for material deficiencies will help communication between material suppliers and construction. PG and HMA are only two examples. (Obtain Failed material policy from IN.)
7. Opportunity to improve liquid binder sampling monitoring. Contractor to be trained by liquid supplier.
8. NTPEP – IL starting to look at them to develop comfort level.
9. TX Risk Assessment document specific to Tiers 1 – 3.
10. Develop Risk Matrix to assist with redeploying efforts either upwards or by reducing testing frequency.
11. Improved database such as those presented by other SHA / SiteManager will enhance IDOT's ability to improve quality and communications between Materials and Construction.
12. Improve pavement quality of HMA through job-site sampling and testing. Improved equipment use, improved sampling and testing, understanding biased testing. (Ready to go but there is some fear of the unknown.)
13. Sharing of cement sampling regionally. Potentially a role for NTPEP after developing on-line for IL, MO, IN, NH, etc. Short-term IL will develop agreement with MO, IN, and IA (recent example).

Figure 18. Measuring QA Peer Exchange Success (Murphy, 2009).

PHASE 3: SUMMARIZING THE FINDINGS

Phase 3 consists of this final report and accompanying documentation summarizing the findings of the study phases, including follow-up with IDOT and key states that participated in the Multi-State Peer Exchange and Materials Testing Workshop.

3.1 RISK ASSESSMENT

A credible and critical risk assessment is part of the successful application of this research study. The delivery and overall performance of the road program shall not be compromised by these recommendations. It is particularly important to realize that all material producers may not be capable of identical levels of competence when it comes to manufacturing products. However, the ability of a company should not sway IDOT's desire for obtaining the highest quality product as often as possible. Generally speaking, most organizations can be graded on their ability by the use of mean and spread of test results (see Figure 20). The benefit to owners is that, by defining quality levels and acceptance levels, then the terms 'use as is,' 'accept,' and 'reject' may be better defined with payment for each level calibrated accordingly.

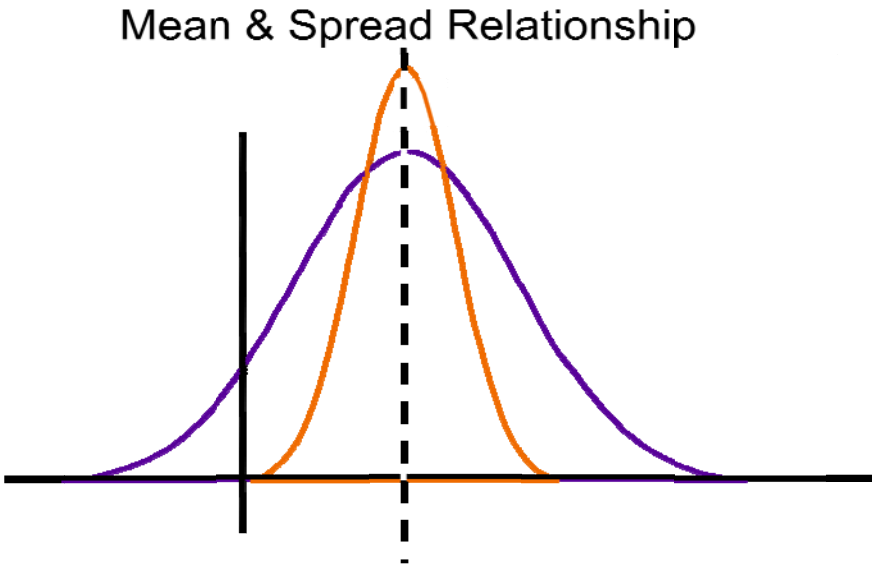


Figure 19. Comparison of two manufactures production capabilities (Murphy, 2010).

Manufacturers must meet IDOT specification requirements and they may improve their capabilities by following various internal auditing processes. One such process is by developing a Pareto chart, a bar graph with the bars sorted in descending order, which is used to identify the largest opportunity for improvement. The purpose of the Pareto chart is to highlight the most important of many variables. In quality control, it represents the most common sources of defects or problematic factors. The left vertical axis is typically the frequency of occurrence, cost, or other unit of measure. The right vertical axis is the cumulative percentage of the total of the particular unit of measure. Overall, the chart can be used to show the most expensive problem or problems that an organization is facing. For example, contractors and manufacturers can use Pareto charts to determine why certain manufactured items are out of specification. Risk assessment should be balanced between manufactures and IDOT. To that end, IDOT must continue to support industry through meetings, specification writing in partnership, educational programs, and continued research.

The most basic format of risk assessment has been in place for many years, yet as the National Highway System grew agencies across the nation found that keeping up with the

changing business practices of material suppliers and contractors forced research, specification development, and compliance criteria to become better defined. By taking a step back and reflecting upon the Uniform Commercial Code (UCC) future redirection on the way we do business can be gathered along with the opportunities presented throughout the QA Peer Exchange.

3.2 UNIFORM COMMERCIAL CODE (UCC)

The UCC, developed under the auspices of the National Conference of Commissioners on Uniform State Laws (NCCUSL) and the American Law Institute (ALI), is part of a larger effort to harmonize the laws governing sales and commercial transactions for all of the United States. To this end, adoption of the UCC promotes local and multi-jurisdictional commerce by striving for uniformity in policies and procedures across State lines. The UCC has been adopted in Illinois, where it has major implications for the local, State, and national economy as well as for public rights.

A basic example of the usefulness of the UCC is when a consumer purchases a new driveway from a construction company. For the purpose of this example, the consumer is uninformed about the implications of aggregate selection for designing a driveway in the Chicagoland climate. Such a consumer will rely on the expertise of the construction company in selecting appropriate materials and tools to deliver the product. Ideally, the construction company will design and deliver an appropriate pavement for the client's needs.

Figure 20. Failing precast concrete median after one winter (Murphy, 2002).

However, the construction company may (inadvertently or intentionally) build a faulty driveway that contains aggregates inappropriate to the northern climate, and then issue the consumer a one-year warranty on the inferior product. If that driveway fails after two winters due to poor design, the construction company may try to refuse to repair their faulty product by claiming that the promised one-year warranty has expired. Under the UCC, this is tantamount to theft because the seller (in this case, the construction company) knowingly provided the consumer with an inferior product, thereby violating the “implied warranty of fitness for particular purpose” (810 ILCS 5/2A-213).

The UCC is a useful device for pursuing redress through legal action on a much larger scale, as well. If a vendor or contractor knowingly supplies IDOT or any of its subsidiaries with a faulty product—regardless of its compliance with specifications issued by the state or federal government—then laws dictate that the offending party pay fines or incur other penalties for their unethical business practices.

CONCLUSION

TOTAL QUALITY MANAGEMENT (TQM)

Total Quality Management (TQM) is systematic problem solving for continuous improvement. It is both a philosophy (based on the work of Edward Deming) and a set of guiding principles that represent the foundation of the continuous improvement process within an organization. Quality is not so much an outcome as a never ending *process* of continually improving your product. As its name implies, TQM focuses on attaining holistic quality. Juran defines quality as "fitness for use" by the customer while Deming contends that quality "should be aimed at the needs of the customer, present and future." By either definition, the customer decides whether a product is of high quality, not the participants in the process that created the product.

In 1996 IDOT began the process of adopting TQM; however keeping after this initiative has lacked ongoing focus and action. From the 1996 final report there is a good example of how to expect QC / QA to work for the contractor and IDOT. Assume that the illustration below is a plot of the number of defects in concrete pavement per mile of pavement. The chart shows four distinct sections. Initially the average is show as 10 defects per one mile. However, as can be seen from Phase A of the chart, the number of defects each mile varied significantly, the process was out of control.

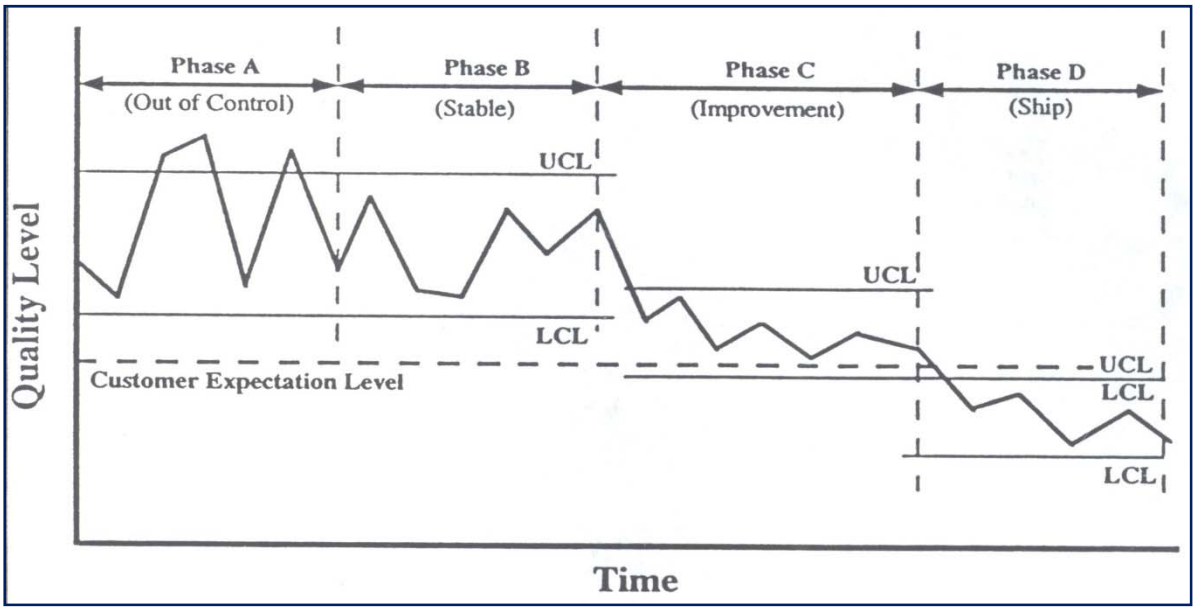


Figure 22. Four sections of QM over time.

By analyzing the cause for the variation in the number of defects in the roadway surface, let us assume that changes in the process were made. As can be seen in Phase B section of the chart, the variation in the number of defects has been reduced significantly. The process is now under control, even though the quality is still considered poor as the number of defects (10) is considered to high. Let us assume further analysis is made of the process. In particular an analysis is made of the time periods and road sections when the number of defects is less than the average of ten. Let us assume that this analysis leads to the implementation of additional improvement ideas. Having implemented these ideas, Phase C and D of the chart indicates that the average number of defects has been reduced; a breakthrough has been obtained. The process has not only been put under control, but it has also been improved.

To help in the process of continual striving for total quality, IDOT's Materials Risk Analysis cannot remain static; it is most useful as a fluid process that stays current through IDOT's involvement with national meetings, as well as participation and leadership in national, regional, and local initiatives for road and bridge performance. For example, a study funded by NCHRP, 10-83 [Request For Proposal] titled "Alternative Quality Management Systems for Highway Construction" is just now beginning (see Appendix 11 for full text). A cursory review of the objectives shows parallels to many of the efforts undertaken through this research project on a much wider scale and with a far broader scope (i.e. Design-Build, Design-Build-Warranty). As the funds allocated for the NCHRP project show, this type of QC / QA progress is taking a priority on a national level. Based on the findings of this research, IDOT should consider taking an active role in the ongoing NCHRP project to help guide the outcome on a nationwide basis; this will ultimately help IDOT continue to solve problems with inspection, sampling, and testing requirements for acceptance.

In the area of materials, machinery, and methods, the IDOT BMPR must be afforded adequate tools and resources to stay "in front of the curve" of increasing traffic volumes and loads, dwindling local materials, and limited out-of-state travel budgets. The BMPR must stay current with new technology and equipment to support the Illinois infrastructure that is enormous, aging, and a capital stock to maintain. As the TRB *Critical Issues in Transportation: 2009 Update* cautions:

> The United States built an enormous transportation infrastructure in the 20th century; replacement would cost trillions of dollars. Roads, bridges, locks, channels, runways, terminals, and rail lines are made of durable materials that appear capable of lasting for many more decades—but will not. On the inland waterways, for example, approximately half of the locks maintained by the U.S. Army Corps of Engineers are more than 50 years old, in use beyond their designed service lives. (This is also true within the state of Illinois).
>
> Maintaining and upgrading the infrastructure is costly. To maintain the condition and performance of the nation's huge inventory of roads and transit systems for the next 20 years, given their current and projected use, would cost all units of government approximately $95 billion per year. Addressing only the deficient structures and pavements that would be cost-beneficial investments and improving system performance would cost approximately $154 billion per year. Actual capital expenditures are about $80 billion. Research can yield cost-saving innovations to extend the service life of these assets. For example, advanced technologies can be used to identify problematic components that can be replaced or repaired before failing. Even taking into account such innovations and the tens of billions of dollars invested annually by all levels of government on surface transportation, the Federal government estimates that the current investment is not sufficient.
>
> Lack of system preservation and rehabilitation produces a downward spiral. Deteriorating infrastructure is largely invisible to the public. Therefore, generating public support for funding rehabilitation and reconstruction is difficult. This problem is not unique to transportation—America's sewers, water systems, and public school facilities also are suffering from deferred maintenance. The short-term savings from deferred maintenance, however, have a price: proportionately greater rehabilitation costs later. This short-term deferred maintenance strategy also raises user costs in the interim, through delays and the wear and tear on vehicles. Raising the visibility and developing financial support for system preservation is critical to the 21st century transportation system. (TRB, 2009)

As the TRB warns, a combination of factors contribute to the continuing deterioration of the transportation infrastructure in the United States. As the cause and effect fishbone analysis

diagram in Figure 23 shows, many issues can lead to a larger overall problem. TQM helps managers and decision-makers see the whole picture, and thus enables more strategic problem-solving efforts that deal with the root causes rather than simply the tip of the iceberg.

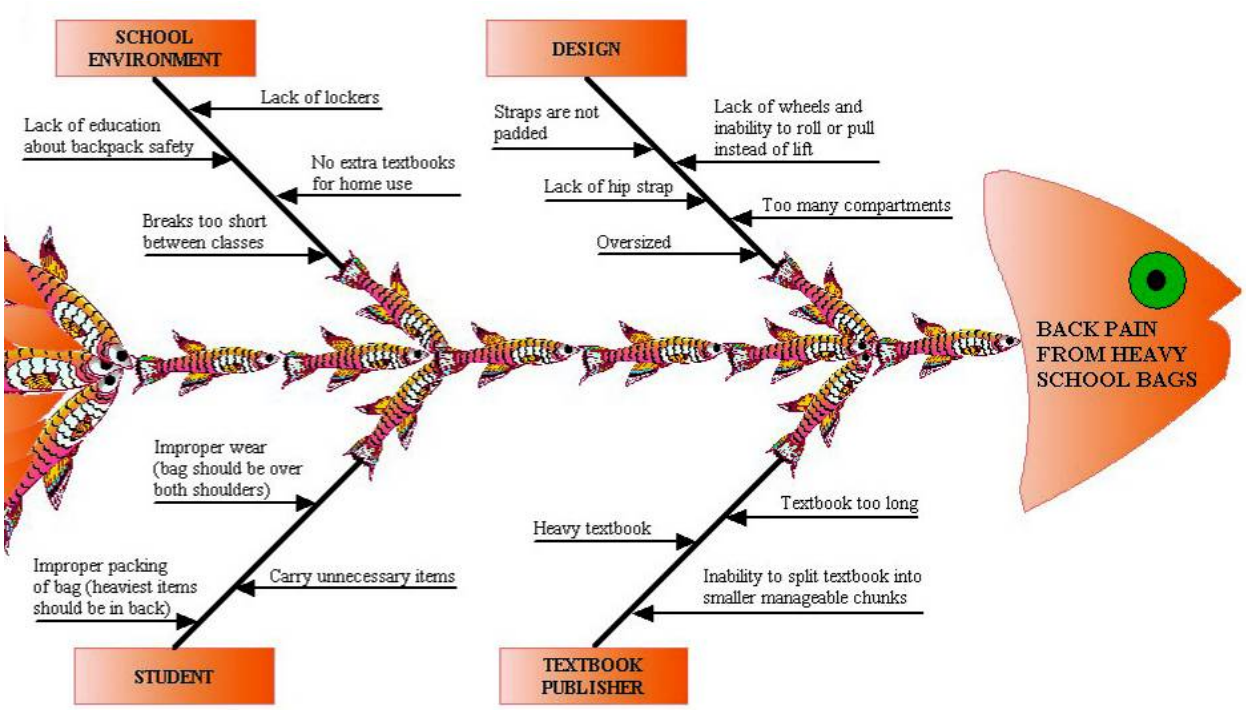


Figure 23. Sample diagram of a fishbone analysis (anonymous).

SUMMARY OF RECOMMENDATIONS

Based on research of materials and methods acceptance practices throughout the nation, conversations and manufacturing site visits with IDOT, working with NHDOT, TXDOT, MODOT, INDOT, FHWA during the QA Peer Exchange, and NTPEP annual and Illinois meetings, the following action items for IDOT BMPR specific to field or off-site manufactured products include:

- Develop matrix of agreed to level of service vs. criticality. (Risk versus Reward)
- Develop Delphi Matrix for all IDOT Districts input. (Risk versus Cost)
- Develop fishbone diagrams for material inspected, sampled, and tested by BMPR.
- Develop a three tier system to completely analyze, interpret, and decide on use for non-compliant materials.
- Institute payment reductions for materials tested that do not meet specification requirements and is left in place.
- Measure supplier competency and issue a report card; reduce inspection at high performing sources and increase inspection at low performing sources.
- Revisit the friction policy and consider how to increase the use of local materials.
- Eliminate annual or tri-annual visits to steel manufacturers who do little to no work with IDOT.
- Increase investment in new equipment purchases and maintenance.
- Reduce travel to increase unit head time in the office working with their staff allowing the managers added opportunity to work with and oversee employees.
- Cross-training employees.
- Develop and implement an improved method of sharing test data across state lines.
- Use Pareta Chart behavior.
- Utilize statistically qualified need for testing versus anecdotal conclusions.
- Continue to generate MISTIC reports for reviews of acceptance testing modification.
- Improve sharing of information throughout all Bureaus; consider SiteManager or equivalent upgrade.
- Continue to streamline testing units wherever practical.
- Inspect, sample, test, and accept HMA and PCC on the grade (jobsite) at its final resting point; on the grade, behind the paver.
- Invite a national QC firm outside of road construction to exchange ideas regularly.
- Attend NTPEP and other national consortiums and become an active leader in these groups.
- Research “Practical Design” for potential use.
- Introduce Uniform Code of Construction principles to IDOT.
- Market BMPR.
- Utilize detailed timesheets. (Use to determine the cost to perform a test).
- Update the PPG accordingly.
- Manage the system and educate Resident Engineers / Technicians on low- to high-risk materials with the value of a test being taken into account for the risk of the product.
- Continue to develop certified producer program for numerous materials.
- Consider recertification of technicians and the development of workmanship training.
- Allow apprenticeships in lieu of mandating certified technicians for all inspection efforts.

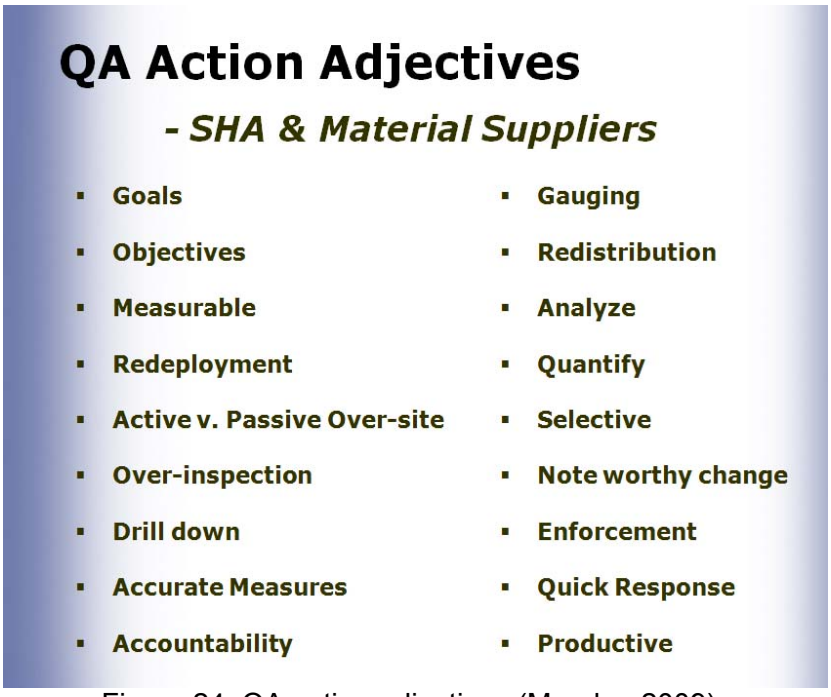


Figure 24. QA action adjectives (Murphy, 2009).

IDOT action items to take ongoing in order for continued success:

In order for BMPR to uphold the Departments commitment to the FHWA it is clear that a continued investment in equipment is of paramount importance. The cost of testing must be weighed and when it is determined that the risk of failure warrants testing, IDOT must have the equipment (maintained, repaired) to attain results.

- Benchmark
  - Grade IDOT v. other State Highway Agencies.
  - Compare test results versus failure rate.
  - Document actions taken.
- Develop a matrix of agreed to level of service v. criticality and revisit every five years.
- Empower others but remain the responsible party that oversees manufacturers, suppliers, contractors, and consultants.

IDOT BMPR should quantify, summarize, and advertise efforts ongoing. Ensure highlights, awards, ongoing initiatives, breakthroughs, and research findings are discussed at least quarterly in some type of Executive Summary newsletter publication. This awareness-raising for the agency as a whole will make others conscious of the efforts continually being made on their behalf by BMPR behind the scenes.

As a final Appendix the BMPR and MPT summarized BMPR accomplishments after the QA Peer Exchange because of the rapid implementation schedule needed to remain successful by IDOT. Appendix 12 shows the list of changes by section and when comparing the appendix with the above summary of recommendations it shows that while great progress has been made additional opportunities should be continue to be pursued. As BMPR continues to refine the QA process, business (operations) approaches to product acceptance (e.g. Pay for Performance (PFP)) should be considered and potentially enhanced by:

- Participating at and becoming national chairpersons to guide future rules and regulations for material approval processes that are established by NTPEP, regional agency groups, and AASHTO.
- Involving / Seeking input from industry representatives as they develop specifications, especially if it appears as though a specification may hold particular relevance to a

certain industry or group (e.g., Associated General Contractors of America, concrete and asphalt associations, etc.) to:
    - Enhance interaction and outreach among State DOT staff and industry representatives.
    - Identify constructability issues or past problems related to enforceability or inconsistent administration in the field.
    - Get their perspective on how the change may impact business or operations. (FHWA Technical Advisory: Development and Review of Specifications; HIAM-20, March 24, 2010).
- Expanding the pay scale concept begun for HMA for all materials used in road building such as:
    - Liquid Asphalt (PG): Reference Appendix 5: *Indiana DOT Failed Materials Policy* example,
    - Portland Cement Concrete,
    - Reinforcement steel and WWF, and
    - Hot poured rubberized joint sealant,

  just to name a few.
- Developing a comprehensive 'sampling' course (0.5-day) on 'Go-To' to assist with the transition to PFP for both IDOT and industry in lieu of requiring Level One HMA,
- Obtaining bill of lading (BOL) for asphalt used on projects and requiring cancelled checks and stamped invoices be supplied with pay vouchers on asphalt projects,
- Developing a manual and providing training to construction, contractors, and consultants: Reference Appendix 3: *Hamilton Sundstrand, D.I.V.E.* example.
- Reviewing material acceptance on a monthly basis to pick up trends in compliance challenges quicker and to make future inspection, sampling, and testing adjustments to the PPG. (i.e. spring versus summer versus fall).
- Maintaining inspection yet reducing sampling and testing on 'low risk' items.

These items are listed in no particular order; however, each has considerable upside to improving the way IDOT does business specific to Quality Assurance.

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APPENDIX 1.

Peer Exchange Presentations

Presentations given at the Peer Exchange by each BMRP Section Head can be found on the ICT website at http://ict.illinois.edu/News/peer-exchange.aspx.

APPENDIX 2.

Minutes of the Illinois Department of Transportation
Bureau of Materials and Physical Research (BMPR) Kick-off Meeting

Overview of QC and QA functions of BMPR

- Discussion with Bureau Chief and Section Chief
- Discussion with Lab Managers
- Lab tours

Multi-pronged Approach to Asset Management / Risk Assessment

- NTPEP – investigate the function of NTPEP and determine applicability BMPR
- Develop questions related to a set of selected processes
    - Metals and Misc – How do other states enforce the Buy America Act?
    - What is the process for structural steel beam acceptance by other states?
    - Chemistry – How do other states approve striping materials / batch lot materials?
    - Aggregate – How do other states accept RAP/FRAP?
    - Concrete – Are other states willing to engage in a regional approval process for select materials?

PEER Exchange – select state materials engineers invited to Springfield in the fall to discuss in-depth key issues

Results from all activities will be applied to affected units for their consideration to accept. A final report will consist of a global assessment of risk management with the quality programs reviewed. Select materials reviewed under all activities will be documented as appendices.

APPENDIX 3.

A manual IDOT should consider developing (similar to Hamilton Sundstrand)

D.I.V.E.

Define the problem
Investigate the problem
Verify the root causes and proposed mistake proofed solutions
Ensure the desired corrective action is implemented and achieved

Define: Market Feedback Analysis

Use objective marketing data to focus on the issues causing customers the most pain and frustration.

Define: Process Feedback Analysis – Problem Identification, Prioritization, and Selection

Use objective process data and employee feedback (Quality Process Clinic Charts) to focus on quality, delivery, and productivity problems.

- Employee-management involvement and trust
- Positive work environment and morale
- Make employees' jobs easier
- Encourage reporting of problems and potential problems
- Capture problem data objectively without emotion
- Prioritize items to be worked (allocate resources)
- Set aggressive improvement goals
- Generate success stories (include cost of poor quality calculations)

Define: Quality Process Clinic Charts (QCPC)

All processes must deliver “first pass through” (100% first time yield or completeness and accuracy) without delays or in-process rework, and do so in the shortest time possible. Anything that prevents this is a *turnback* (waste). Each turnback is a golden nugget, because it tells a story about why and how it occurred. (There are no isolated incidents.)

QCPC is a simple tool used to map the sequence of activities in a process, to record turnbacks, and to discover opportunities for improvement.

Define: Priorities

Pareto charts help identify top problem areas. The work are team then performs root cause analysis and implements corrective action to resolve the most important turnbacks.

Investigate: Clinic Activity

- Rapid Failed / Problem Product Retrieval
- In-house Capabilities to Analyze Root Causes
- Rapid Feedback to Group Generating the Product
- Mistake Proof Solution Developed and Implemented
- Ensure Incorporation of Lessons Learned into Standard Work
- Actively Involve Top Management in Progress

Investigate: Relentless Root Cause Analysis (RRCA)

Pursuing relentlessly and with speed the source of a problem until all root causes are discovered. For Example:

- Why are corrective actions ineffective? They don't address the root causes of the problem.
- Why don't the actions address root causes? The wrong root causes were identfied.
- Why were the wrong root causes identify? The team members were improperly trained in RRCA.
- Why were the team members improperly trained? Training in Quality has not been a priority.
- Why has training not been a priority? Management has not been educated in the benefits of "Quality First."

Investigate: Mistake Proofing

Using wisdom, ingenuity, and brainstorming to create devices that allow you to do your job 100% defect free, 100% of the time. When selecting concept for mistake proof devices, you should be able to answer *yes* to all of the following:

- Irreversible corrective action?
- Minimal cost?
- Simple to use?
- Easy to install and maintain?
- Durable?
- Does not hinder user / operator?

Validate: Root Causes

Final test of this activity: Do the identified root causes apply to another part or process?

Is there more than one root cause? Yes
Does the root cause statement identify an element of a process? Yes
Are the root cases controllable? Yes
Can you ask "why?" one more time and get another controllable root cause? No
Are our identified root causes fundamental breakdowns or failures of the process? Yes
If we correct / improve the root causes we have identified, will that ensure that the problem will not recur? Yes
Have we identified the root causes of the problem? Yes

Validate: Level of Mistake Proofing

Level 1: Problem prevented from ever occurring at its source *(physical / logical elimination of source)*

Level 2: Problem detected and corrected during the process *(administrative intervention)*

Level 3: Problem detected after the process but before exposure to the consumer *(post-process inspection and intervention)*

Ensure: Effectiveness of Corrective Actions

Ensuring that the mistake proof solution(s) are properly implemented and working effectively.

- Define a control plan for gathering and analyzing process data (e.g. Elephant

Chart and Quality Clinic Process Chart)

- Monitor the corrected process and identify new improvement opportunities
- Document the new process; update standard work with best practices and lessons learned
- Document the success story
- Celebrate: recognize and reward contributors

(Summarized from Hamilton Sundstrand published materials.)

APPENDIX 4.

Full Text of the Proposed Quality Assurance Peer Exchange Nationwide Questionnaire

1. Specification Conformity Analysis (SCA), as developed by the FHWA, is a part of the Highway Condition and Quality of Highway Construction Surveys and is typically performed in an on-going way with an annual report to the FHWA. We believe that the SCA is used to estimate the degree of compliance with specifications and to provide an indication of construction quality. What methods have you developed that give your state the greatest return on maintaining your construction quality? (e.g. Qualified technicians, training, industry or agency forums, new products, experimental features, etc.)

2. Did the FHWA Technical Advisory titled "Use of Contractor Test Results in the Acceptance Decision, Recommended Quality Measures, and the Identification of Contractor / Department Risk", (dated 8/9/1999) require changes to your acceptance process for road building efforts? If so, what positive revisions did you initiate?

3. Do you accept non-conforming products to remain in-place? If you have penalties for these products accepted in the work, please share examples of penalties for three critical materials used in road and bridge construction with regards to acceptance analysis and your perspective on how penalty charts have been developed over the years.

4. Do you use contractor Quality Control (QC) test results as part of the payment for asphalt, concrete, and / or any other manufactured product?

5. Where do you perform aggregate Quality Assurance (QA)? (e.g. At the pit, the quarry, the asphalt and / or concrete facility, etc.) Please differentiate between aggregate gradation and quality.

6. Who is responsible for ensuring that pretested material delivered to the project has been tested? What QC / QA procedures are in place for pretested material?

7.1. Do you utilize National Transportation Product Evaluation Program (NTPEP) for first article acceptance? Which products?

7.2. What do you feel are three strengths of NTPEP and what may be the future focus of this organization?

7.3. Please list three opportunities for improving NTPEP specific to materials acceptance.

8.1. Does your agency use a materials data management system (such as SiteManager™)? If so, please describe how it functions and it is kept up to date. What decisions are made based on the data? If not, what process is in place for data management?

8.2. Do you feel it is practical to develop a region and potentially national data base where verification, independent assurance, and acceptance testing of materials can be shared between States? If so, who should take the lead?

9. Has your state developed a risk matrix (or grouping) that acknowledges both the potential for a material to fail to meet specification requirements and the magnitude (consequences) of the failure to the motoring public? If so, please attach the matrix for our consideration and provide a short summation of how you developed such a matrix for your state. If not, what is

your typical response to a situation where material fails and what are typical consequences for a failed material?

10.1. Does your state agency use consultants in the verification, independence assurance, and / or acceptance process of materials inspection, sampling, and testing? If so, how do you manage the program?

10.2. How do you qualify laboratories that act on behalf of the agency in terms of quality assurance for aggregates, geotechnical, asphalt, and concrete materials? Who performs the preliminary laboratory inspection?

11. Specification Conformity Analysis (SCA); Please rate the following statements on a scale of 1 – 4, with 4 being strongly agree and 1 being strongly disagree.

	1 Strongly Disagree	2 Disagree	3 Agree	4 Strongly Agree
Can be effectively used to estimate the degree of conformity to specification requirements that is being achieved on a project or for a particular construction process.				
Can identify specification requirements which are impractical or ineffectual in assuring good performance.				
Are useful for relating the degree of conformity to specifications with product performance.				
Are useful for evaluating contractors' process control capabilities.				
Are useful for monitoring the degree of control over a period of time.				
Can be used to determine when to increase or decrease sampling and testing frequencies from the approved frequencies.				
Are being used successfully on projects in specifications for the acceptance of materials.				

12. How do you accept reinforcement steel for use in roads, bridges, and structures?

13. How do you perform acceptance for pre-stressed concrete I-beams?

14. How do you perform acceptance for structural steel?

15. How do you perform acceptance of signs, stripping, and paints?

16. At what location do you inspect, sample, and test Hot Mix Asphalt?

17. At what location do you inspect, sample, and test Portland Cement Concrete used for pavements, bridges, and other appurtenances?

18. How do you perform acceptance of bridge bearings such as rockers and elastomeric bearing pads? If different products are used please define and explain your system.

19. Please comment on the following statement, ‘Most producers and manufacturers take care in producing materials that will meet specification and very few materials regularly fail to meet specification.’

20. The intent of the material certification is to assure that the quality of all materials incorporated into the project is in conformance with the plans and specifications and thus ensure a service life equivalent to the design life. An exception is considered to be any material represented by an acceptance test that is shown to not meet the criteria contained in the plans and specifications. The exceptions should be reviewed to determine if in fact the material is in reasonably close conformity with the plans and specifications.

21. Do you treat acceptance responsibilities on a project by project basis or system wide? For example, for a given hot mix asphalt being produced at one facility; if 200,000 tons are produced in 12-months time do you inspect, sample, and test based on the annual production or per job following a certain frequency?

22. Do you share material test results with local agencies and municipalities or other agencies?

23. How do you ensure compliance with the domestic steel policy? Do you train field staff as well as material source inspectors? Do you issue waivers and if so, for what?

APPENDIX 5.

Failed Materials Policies

*This is an example special provision showing payment deductions from Indiana. A more comprehensive review of numerous states from around the nation is attached as an Excel spreadsheet but not printed for the sake of reducing the size of the final report. It can be made available to reviewers as a file attachment.

INDIANA DOT FAILED MATERIALS POLICY

Effective Date: 4/6/09 Approved: _____
Supersedes Policy 13-4 Dated 4/27/06 James Poturalski
Deputy Commissioner
Highway Management

POLICY

Material or a finished product determined not to be in accordance with the applicable specifications or tolerances will be designated as a failed material. Failed materials will be reviewed to determine whether the material has resulted in acceptable work and should remain in place in accordance with 105.03. If the failed material is allowed to remain in place, a quality adjustment will be determined in accordance with 109.05.1.

GUIDELINES

Failed Materials Committee

The Failed Materials Committee will consist of the following:

1. Director, Construction Management Division, Chairman
2. Manager, Office of Materials Management
3. State Construction Engineer
4. District Technical Services Director

A quorum of the Chairman and two members of the Failed Materials Committee will be required for adjudication of a failed material, except where that authority has been delegated to the District Testing Engineer or Manager of the Office of Materials Management. The adjudication for all materials where the adjudication would be to remove and replace the material will be determined by the Failed Materials Committee. The Chairman will cast a vote only if there is a tie vote among the Failed Materials Committee members.

The Failed Materials Committee will meet upon call of the Chairman.

Procedures

The Manager, Office of Materials Management will prepare an agenda for each meeting. The items considered will be the failed materials which have not been resolved by previous action. For each item considered, the agenda will list the following:

1. Contract, Purchase Order, or Permit number
2. The name of the material
3. The laboratory or test number
4. A statement of the reason for the failure
5. The specification requirement

6. A summary of comments made by the Project Engineer/Project Supervisor and District Testing Engineer on the failed materials report
7. Supporting information or documentation

The Failed Materials Committee will review all of the information available for each failed material item to determine whether the failure will require removal of the material. If the Failed Materials Committee determines that the work is acceptable, an appropriate adjustment in pay and/or remedial measures will be determined. The Failed Materials Committee will set guidelines as necessary to provide for efficiency and uniformity of evaluation of the failed material.

A letter will be written to the Prime Contractor by the Manager, Office of Materials Management, concerning the Failed Materials Committee decision regarding the failed material. Copies will be sent to the District Construction Director, Project Engineer/Project Supervisor, District Testing Engineer, Producer, if applicable, and Committee members.

Appeals

The Prime Contractor may appeal the decision of the District Testing Engineer, Manager of the Office of Materials Management or Failed Materials Committee by sending written notification to appeal to the Chairman within 15 days of the date of written or electronic notification of the failure. The basis of appeal in detail shall be included in the written notification. The Chairman will review the appeal and send the decision in writing to the Prime Contractor.

District Testing Engineer

The District Testing Engineer is authorized to adjudicate a failed material and assess a quality adjustment for all failed materials with a credit schedule defined in the Failed Materials Policy Appendix.

The District Testing Engineer will prepare a report for materials which fail to meet the applicable requirements of the Standard Specifications. The District Testing Engineer may consult with the Office of Materials Management in determining whether additional testing is needed or to verify the contents of the report. Failed materials not included in the Failed Materials Policy Appendix will be submitted to the Office of Materials Management. The failed materials submittal will include the quality control tests, original acceptance tests, and the appeal test results, if applicable.

Manager, Office of Materials Management

The Manager, Office of Materials Management, is authorized to adjudicate a failed material for those materials with a credit schedule defined in the Failed Materials Policy Appendix where the value indicates FMC and other failed materials that do not require remove and replace adjudication.

Effective Date: 4/6/09

FAILED MATERIALS POLICY APPENDIX

GENERAL

1. The credits will be cumulative to determine the total credit to be assessed.

2. The following table will be used to assess the quality adjustment:

Calculated Credit	Quality Adjustment
0 - $200.00	$200
$200.01 - $500.00	$500
$500.01 and above	The actual calculation

3. The cost of any additional sampling, testing, and analysis of test results that was required to determine the acceptability of the material will be included in the quality adjustment when the material is left in place. A minimum of $250 or the actual cost of the investigation will be assessed.

4. The District Testing Engineer will determine all of the quality adjustments listed in the following tables except where FMC is indicated, which will require the adjudication by the Failed Materials Committee.

HOT MIX ASPHALT (HMA)

For assessing a credit to the contract, the following material values will be used:

HMA Curbing ---------- Binder Index @ 7.0% + $15.00/ton aggregate @ 93.0%

HMA for Temporary Pavement

- Base ---------- Binder Index @ 4.5% + $15.00/ton aggregate @ 95.5%
- Intermediate -------- Binder Index @ 5.0% + $15.00/ton aggregate @ 95.0%
- Surface ---------- Binder Index @ 6.0% + $ 15.00/ton aggregate @ 94.0%

HMA Patching

- Base ---------- Binder Index @ 4.5% + $15.00/ton aggregate @ 95.5%
- Intermediate -------- Binder Index @ 5.0% + $15.00/ton aggregate @ 95.0%

Effective Date 4/6/09

The following credit schedules will be applied to the contract bid price of the mixture:

Mixture

AIR VOIDS	
Deviation from DMF/JMF (%)	**% Credit**
> 1.5 and ≤ 1.7	5
> 1.7 and ≤ 1.9	10
> 1.9 and ≤ 2.1	20
> 2.1 and ≤ 2.3	30
> 2.3 and ≤ 2.5	50
> 2.5	FMC
BINDER CONTENT	
Deviation from DMF/JMF (%)	**% Credit**
> 0.7 ≤ 1.5	5.0 for each 0.1 % above 0.7
> 1.5	FMC

Low Temperature Density

Percentages based on % MSG	% Credit
≥ 97.0	FMC
91.0 - 91.9	0.4 for each 0.1 % below 92.0
90.0 - 90.9	4.0 + 0.8 for each 0.1 % below 91.0
88.0 - 89.9	12.0 + 2.0 for each 0.1 % below 90.0
≤ 87.9	FMC

COLD MIX ASPHALT (CMA)

The following credit schedule will be applied to the contract bid price of the mixture:

Test	% Credit
Gradation	For each 0.1% -- 0.1 % credit
Asphalt Content	For each 0.1% -- 5 % credit
Crushed Content	For each 0.1% -- 0.2 % credit

Effective Date 4/6/09

PERFORMANCE GRADED ASPHALT BINDERS

More than one credit per binder sample may be assessed. The following credit schedule will be applied to the binder index for the month of the failure.

Dynamic Shear Rheometer			**Bending Beam Rheometer**			**Bending Beam Rheometer**		
RTFO Material			**PAV Material**			**PAV Material -- M value**		
Required: ≥ 2.20 kPa			**Required: ≤ 300 Mpa**			**Required: ≥ 0.300**		
		%Credit			%Credit			%Credit
2.10	< 2.20	2.5	> 300	315	2.5	0.285	< 0.300	2.5
2.00	< 2.10	5.0	> 315	330	5.0	0.270	< 0.285	5.0
1.90	< 2.00	10.0	> 330	345	10.0	0.255	< 0.270	10.0
1.80	< 1.90	15.0	> 345	360	15.0	0.240	< 0.255	15.0
1.70	< 1.80	20.0	> 360	375	20.0	0.225	< 0.240	20.0
1.60	< 1.70	30.0	> 375	390	30.0	0.210	< 0.225	30.0
1.50	< 1.60	40.0	> 390	405	40.0	0.195	< 0.210	40.0
1.40	< 1.50	50.0	> 405	420	50.0	0.180	< 0.195	50.0
N/A	< 1.40	*	> 420	N/A	*	N/A	< 0.180	*

* Credits in excess of 50.0 % for an individual test or the accumulation of an excess of 50.0 % for all tests will be adjudicated by the Failed Materials Committee.

QC/QA HOT MIX ASPHALT -- Open Graded Mixtures

Binder Content -- Sublots with a binder content deviation from the JMF greater than 1.0% will be assessed a binder content pay factor of 0.00.

Air Voids -- Sublots with an air void deviation from the JMF greater than 4.0% will be assessed an air void pay factor of 0.50.

QC/QA HOT MIX ASPHALT -- Dense Graded Mixture ≥ One Lot

Lot PWL values for the binder content, air voids, VMA, or in-place density (%Gmm) less than 50 will have pay factors determined from the following formula and as indicated in the table.

$$PF = \frac{100 - \left(0.000020072x(100 - PWL)^{3.5877}\right)}{100}$$

Pay Factors										
PWL	9	8	7	6	5	4	3	2	1	0
40	0.73	0.71	0.69	0.67	0.65	0.62	0.60	0.57	0.55	0.52
30	0.49	0.46	0.43	0.39	0.36	0.32	0.29	0.25	0.21	0.16
20	0.12	0.07	0.03	FMC	FMC	FMC	FMC	FMC	FMC	FMC
10	FMC	FMC	FMC	FMC	FMC	FMC	FMC	FMC	FMC	FMC
0	FMC	FMC	FMC	FMC	FMC	FMC	FMC	FMC	FMC	FMC

Effective Date 4/6/09

QC/QA HOT MIX ASPHALT -- Dense Graded Mixture < One Lot

Binder Content -- Sublots with a binder content deviation from the JMF greater than 1.0% will be adjudicated by the Failed Materials Committee.

Air Voids -- Sublots with an air void deviation from the JMF greater than 2.0% will be assessed a Sublot Composite Pay Factor (SCPF) as follows:

Air Voids, %		Deviation	SCPF
1.9	6.1	2.1	0.69
1.8	6.2	2.2	0.62
1.7	6.3	2.3	0.55
1.6	6.4	2.4	0.48
1.5	6.5	2.5	0.42
1.4	6.6	2.6	0.35
1.3	6.7	2.7	0.28
1.2	6.8	2.8	0.22
1.1	6.9	2.9	0.15
1.0	7.0	3.0	0.09
< 1.0	> 7.0	FMC	

VMA -- Sublots with a VMA deviation from the JMF greater than 2.5 % will be assessed a VMA pay factor of 0.00.

Density -- Sublots with an in-place density (%Gmm) ≥ 97.0% or ≤ 88.9% will receive a Sublot Composite Pay Factor (SCPF) as follows:

Density, % Gmm		SCPF
88.9	97.0	0.53
88.8	97.1	0.50
88.7	97.2	0.45
88.6	97.3	0.42
88.5	97.4	0.38
88.4	97.5	0.35
88.3	97.6	0.32
88.2	97.7	0.27
88.1	97.8	0.23
88.0	97.9	0.20
< 88.0	> 97.9	FMC

APPENDIX 6.

NTPEP Brochure

The following pages include a brochure distributed by NTPEP, as well as items NTPEP representatives covered at BMPR and discussed at the NTPEP annual meeting.

NTPEP

DataMine

Datamine

DataMine is our online database of product reports. It can be accessed at **http://data.ntpep.org** DataMine is an online engineering tool for querying, analyzing and reporting on current and past NTPEP evaluations. The database allows dynamic queries of multiple products and specification overlays. DataMine includes features for graphical presentation of results. This offers real time review, publication and analysis of data.

What State Members are Saying about NTPEP

NTPEP allows us to actually "Do more with less", by combining the resources of the DOTs.

—Robert Sarcinella *(TX)*
Materials Branch Manager

NTPEP provides national consensus specifications for materials testing as well as third party independent data for transportation agencies, industry and the public at large.

—Dave Kuniega *(PA)*
Chief Chemist, Bureau of Construction and Materials

Easy method to generate Approved Product Lists

—Jim McGraw *(MN)*
Chemical Laboratory Director

NTPEP saves my state money or improves quality, or both.

—Tom Baker *(WA)*
State Materials Engineer

15 ANNIVERSARY 1994 2009 NTPEP

For More Information Please Contact:

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Henry Lacinak, Jr., PE
NTPEP Staff Liaison
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hlacinak@aashto.org

Or visit our website:
www.ntpep.org

January 2009

A Guide to

NTPEP

AASHTO's National Transportation Product Evaluation Program

American Association of State Highway and Transportation Officials
444 North Capitol Street, NW Suite 249
Washington, DC 20001

www.transportation.org
www.ntpep.org

AASHTO
THE VOICE OF TRANSPORTATION

What Is NTPEP?

The National Transportation Product Evaluation Program (NTPEP) was established by AASHTO in 1994, modeled on successful programs that operated for many years under the direction of the Southeast Association of State Highway and Transportation Officials (SASHTO) and the Northeast Association of State Transportation Officials (NASTO).

By combining the professional and physical resources of AASHTO's member departments to test materials of common interest, NTPEP:

- Reduces duplicate testing among states, providing cost savings.
- Provides industry with a central source for the evaluation of products for the highway market.

Our Goal: Shared Information

The testing and evaluation performed under AASHTO's NTPEP provides information to the states to evaluate a range of products, materials, or devices. This test data may also be used to compare the performance of similar products, materials, or devices.

NTPEP provides the industry with a focal point to initiate the process of evaluating and testing of products, materials, or devices for the AASHTO member departments through one organization.

The NTPEP process neither accepts nor rejects materials. NTPEP provides test and/or evaluation results to participating member departments who can then make their own judgment in selecting products, materials, or devices.

Products Currently Being Evaluated

Traffic Safety Products

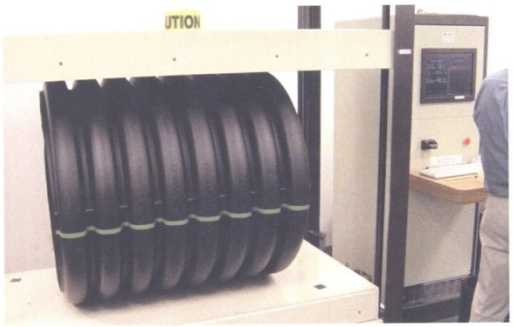
- Portable Changeable Message Signs
- Pavement Marking Materials
- Delineators/Drums
- Raised Pavement Markers and Adhesives
- Sign Sheeting Materials
- Roll-Up Sign Materials
- Snow Plowable Raised Pavement Markers

Construction Materials

- Concrete Admixtures
- Concrete Curing Compounds
- Erosion Control Products
- Geotextiles
- Geosynthetic Reinforcement
- HDPE Pipe Plant Audit
- Reinforcing Steel Mill Audit
- Joint Sealant Material for PCC Pavement

Maintenance Materials

- Polymer Bridge Deck Overlay
- Crack Sealant Material for HMA Pavement
- Rapid Set Concrete Patching Material
- Structural Steel Coatings



How to Have a Product Evaluated

If your product or material falls under one of the Technical Committees listed, please contact the NTPEP Project Engineer for information regarding evaluations and schedules. In order to expand testing for other products, materials or devices, a yearly survey is conducted with member agencies to determine what additional project panels should be established to serve the state DOT's needs.

Who Is Involved with NTPEP?

State Departments of Transportation and industry are partners in the success of NTPEP.

The program is guided by the NTPEP Committee which is comprised of representatives from AASHTO member departments. Technical Committee members who provide guidance for testing procedures and protocols are subject matter experts from member departments and technical experts from industry.

Testing Protocol

A technical committee is formed for each product category. The technical committee creates a project workplan utilizing standardized test methods from AASHTO and ASTM. In some instances, the technical committee may develop test methods, if needed. This workplan is then balloted by the NTPEP committee.

AASHTO'S NATIONAL TRANSPORTATION PRODUCT EVALUATION PROGRAM
List of Technical Committees

Traffic Safety:	Chair	AASHTO Staff Liaison
• Pavement Marking Materials (PMM)	Dave Kuniega (PA) 717-787-3966	Keith Platte 202-624-7830
• Portable Changeable Message Signs (PCMS) • Flashing Arrow Panels (FAP)	Chris Peoples (NC) 919-329-4090	Greta Smith 202-624-5815
• Sign Sheeting Materials (SSM) • Roll Up Signing Materials (RUP)	Jim Swisher (VA) 804-328-3121	Katheryn Koretz 202-624-3695
• Raised Pavement Markers (RPM) • Snow-Plowable Raised Pavement Markers (SRPM)	Don Wishon (GA) 404-363-7632	Greta Smith 202-624-5815
• Temporary Traffic Control Devices (TTCD)	Danny Lane (TN) 615-350-4175	Evan Rothblatt
Construction:		
• Concrete Admixtures (CADD)	Todd Bennett (MO) 573-751-1045	Greta Smith 202-624-5815
• Concrete Curing Compounds (CCC)	Curt Niehaus (KS) 785-296-3899	Greta Smith 202-624-5815
• Erosion Control Products (ECP)	Pete Kemp (WI) 608-246-7953	Keith Platte 202-624-7830
• Geotextiles and Geosynthetics (GTX) • Geosynthetic Soil Reinforcement (REGEO)	Tony Allen (WA) 360-709-5450	Keith Platte 202-624-7830
• HDPE Plastic Pipe (PIPE)	Dave Meggers (KS) 785-291-3845	Katheryn Koretz 202-624-3695
• Reinforcing Steel (REBAR)	Robert Sarcinella (TX) 512-506-5933	Katheryn Koretz 202-624-3695
• PCC Joint Sealants (JS)	Michael Rafalowski (FHWA) 202-366-1571	Greta Smith 202-624-5815
Maintenance:		
• Polymer Concrete Bridge Deck Overlays (PCBDO)	Ken Berg (UT) 801-965-4321	Henry Lacinak 225-752-2877
• HMA Crack Sealant (CS)	Michael Rafalowski (FHWA) 202-366-1571	Greta Smith 202-624-5815
• Rapid Set Concrete Patch Materials (RSCP)	Ross Mills (KY) 502-564-3160	Greta Smith 202-624-5815
• Structural Steel Coatings (SSC)	Derrick Castle (KY) 502-564-3160	Greta Smith 202-624-5815
DataMine:		
• DataMine Technical Committee	Jason Davis (LA) 225-248-4106	Keith Platte 202-624-7830

September 2009

APPENDIX 7.

NTPEP / IDOT Peer Exchange Meeting Participant List
September 15, 2009

Name	Organization	E-mail Address
Todd Bennett	Missouri DOT (CADD)	Todd.Bennet@mo.gov
Julie Beran	IDOT/Materials	Julie.Beran@illinois.gov
Sheila Beshears	IDOT/BMPR	Sheila.Beshears@illinois.gov
Doug Dirks	IDOT/BMPR/Concrete & Soils	Douglas.Dirks@illinois.gov
Jerry Hammitt	IDOT/BMPR	Jerry.Hammitt@illinois.gov
Terence Havard	IDOT/BMPR	Terry.Havard@illinois.gov
Ed Hughes	IDOT/BMPR/Metals	Edward.Hughes@illinois.gov
Scott Hughes	IDOT/Materials	Scott.Hughes@illinois.gov
Katheryn Koretz	AASHTO – Pipe / Rebar	kkoretz@aashto.net
Henry Lacinak	AASHTO	hlacinak@aashto.org
David Lippert	IDOT/BMPR	David.Lippert@illinois.gov
Ryan McLean	IDOT/Materials	Ryan.McLean@illinois.gov
Kelly Morse	IDOT/Materials	Kelly.Morse@illinois.gov
Matt Mueller	IDOT/BMPR	Matthew.Mueller@illinois.gov
Timothy Murphy	Murphy Pavement Technology, Inc.	tmurphy@murphypavetech.com
Dennis Oehmke	IDOT/BMPR/Materials	Dennis.Oehmke@illinois.gov
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Del Reeves	D6 Materials	Del.Reeves@illinois.gov
Ray Rowden	IDOT/BMPR/Metals	Raymond.Rowden@illinois.gov
Robert Sarcinella	Texas DOT (Rebar / Pipe)	rsarcin@dot.state.tx.us
Will Stalcup	Missouri DOT	William.Stalcup@modot.mo.gov
Dan Tobias	IDOT/Materials	Daniel.Tobias@illinois.gov
Jim Trepanier	IDOT/BMPR/HMA	James.Trepanier@illinois.gov
Brad Young	Ohio DOT (SRPM)	Brad.Young2@dot.state.oh.us
Hal Wakefield	FHWA	Hal.Wakefield@dot.gov
Melinda Winkelman	IDOT/Materials	Melina.Winkelman@illinois.gov

"NTPEP / Illinois DOT Peer Exchange"
September 15, 2009
Official Agenda

Location: Illinois Department of Transportation
126 East Ash Street
Springfield, IL 62704

8:00 am Introductions

8:15 am Overview of the NTPEP Program (by NTPEP staff)

9:15 am Illinois DOT Product Approval Process (by Illinois staff)

9:30 am Break

9:45 am Presentation of NTPEP DataMine – Electronic data acquisition for products tested by NTPEP

10:30 am Open discussion / lead into NTPEP Audit Program to be discussed in detail in afternoon session

11:30 pm Break for lunch

12:30 pm Facilitator explains ground rules for peer exchange sessions

Break out into concurrent sessions to receive presentation of materials from NTPEP Lead States.
Facilitated session for dialogue on current product approval requirements and experience.
Discuss what would need to take place to best utilize NTPEP results to meet the needs of Illinois DOT

2:30 pm Summary presentation by facilitators (5-10 minutes each); final changes or thoughts by group members

2:45 pm Final Discussion – Questions and Answers

3:30 pm Adjourn

The four product categories to be discussed in detail during the peer exchange will be Reinforcing Steel, HDPE Plastic Pipe, Snow Plowable Raised Pavement Markers and Concrete Admixtures.

Personnel scheduled for the peer exchange are as follows:

- Robert "Sarc" Sarcinella (Texas DOT) and Katheryn Koretz (AASHTO) for Reinforcing Steel and HDPE Plastic Pipe (These two categories will be presented in the same breakout session.)
- Brad Young (Ohio DOT) for Snow Plowable Raised Pavement Markers – by conference call
- Todd Bennett (Missouri DOT) for Concrete Admixtures
- Henry Lacinak will be participating on behalf of AASHTO Engineering staff and assisting with the Snow Plowable Raised Pavement Marker presentation by Brad Young

APPENDIX 8.

Quality Assurance Peer Exchange Materials Testing Workshop Attendance Sheet

Name	Organization	E-mail Address
Kyaw Aung	IDOT/BMPR/HMA	Kyaw.Aung@illinois.gov
Christian Bakare	IDOT/BMPR/Concrete	Christian.Bakare@illinois.gov
Todd Bennett	Missouri DOT	Todd.Bennet@modot.mo.gov
Sheila Beshears	IDOT/BMPR	Sheila.Beshears@illinois.gov
Patty Broers	IDOT/BMPR/Research Coord.	Patricia.Broers@illinois.gov
Tom Bukowski	IDOT/BMPR/Research Coord.	Thomas.Bukowski@illinois.gov
Doug Dirks	IDOT/BMPR/Concrete & Soils	Douglas.Dirks@illinois.gov
Jerry Hammitt	IDOT/BMPR	Jerry.Hammitt@illinois.gov
Terence Havard	IDOT/BMPR	Terry.Havard@illinois.gov
Ed Hughes	IDOT/BMPR/Metals	Edward.Hughes@illinois.gov
David Lippert	IDOT/BMPR	David.Lippert@illinois.gov
Jody Meador	IDOT/BMPR	Jody.Meador@illinois.gov
Matt Mueller	IDOT/BMPR	Matthew.Mueller@illinois.gov
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Jim Trepanier	IDOT/BMPR/HMA	James.Trepanier@illinois.gov
Hal Wakefield	FHWA	Hal.Wakefield@dot.gov
Ron Walker	Indiana DOT	rwalker@indot.in.gov
Tom Zehr	IDOT/BMPR/HMA	Thomas.Zehr@illinois.gov

APPENDIX 9.

Bureau of Materials and Physical Research, Springfield, Illinois
Quality Assurance Peer Exchange and Materials Testing Workshop Agenda
October 19-21, 2009

Monday, October 19, 2009 (BMPR, 126 East Ash Street)

8:00 AM	Welcome / Introductions
8:10	Kick off / reason and expectations for Exchange
8:15	Illinois QA programs (5-8 minute presentation per unit) Q&A
9:00	New Hampshire QA programs (40 min+/- presentation followed by Q&A)
10:30	Break
10:40	Tour of labs
11:45	Lunch
12:45 PM	Indiana QA programs (40 min+/- presentation followed by Q&A)
2:30	Break
2:45	Missouri QA programs (40 min+/- presentation followed by Q&A)
4:15 PM	Risk vs. QA programs – Assignment for next day Is Illinois missing a QA program or test – are we at risk? Are there programs that should be dropped / modified – i.e. too much effort being spent on low risk testing program?

Tuesday, October 20, 2009 (Illinois Division FHWA, 3250 Executive Park Drive)

8:00 AM	Overview of day
8:10	Go-To-Meeting presentation Q&A with Texas DOT
9:30	Discussion topic: NTPEP program – States use / comfort level
10:00	Break
10:15	Right sizing – Where should new staff / equipment be deployed to provide the most benefit / reduce risk to state the most
11:45	Lunch
12:45 PM	Basic improvement to materials What test / mix parameter should be adopted to improve materials (primary HMA, PCC, precast / prestressed, aggregates plus others)?
2:50	Break
3:00 PM	Local Project Tour

Wednesday, October 21, 2009 (Illinois Division FHWA, 3250 Executive Park Drive)

8:00 AM	Peer exchange member take away / PowerPoint report development
10:00	Management close out
12:00 PM	Departures

APPENDIX 10.

Take-Away Comments from Visiting State Departments of Transportation (DOTs)

Alan Rawson, New Hampshire DOT

1) Investigate a regional or national approach to cement verification testing. The testing of Portland cement is being conduct by most State transportation agencies, but the test failure rate is very low. Based on the repeatedly verified quality of the Portland cement, a regional or national approach to testing could result in significant savings for each State.

2) Review Texas and Washington materials risk assessment programs for potential use. A risk assessment would help ensure that limited testing resources are being directed toward the higher risk products.

3) Develop an on-line materials and testing manual hopefully as comprehensive as IDOTs. This would greatly benefit both internal and external customers.

4) Evaluate the development of an HMA producer certification program to provide an alternate acceptance method for local government. This would provide with greater confidence as to product quality and ensure compliance with Federal requirements.

5) Consider eliminating all concrete plant inspection. PCC has tests that can be completed on the paste and hardened product that are good indicators of long-term material performance. With the implementation of end-result specification states have moved away from concrete plant inspection. Can we now eliminate concrete plant inspection for concrete items that are method specifications? (Indiana does not perform concrete plant inspection.)

6) Approved producer quality management programs should be considered as a requirement for products being accepted by solely by certification. A producer quality management system will provide a higher confidence that products comply with the specifications.

7) Consider revising aggregate ASR qualification for ASTM 1260 from 0.1 to 0.08 percent. This would provide greater assurance that concrete ASR would not be a pose a problem over the long term.

8) Continue to use NTPEP test result to the greatest degree possible to quality products for use.

Indiana DOT

1. InDOT will be getting more involved in NTPEP. Since the QA Peer Group meeting, we have hosted some of the NTPEP staff and will be revising our specifications to take advantage of the many services they provide. We expect to be able to reduce our time and testing efforts in some areas by requiring Producers to submit materials to NTPEP for testing and revise our procedures to do more verification testing.

2. We will investigate the use of the Micro-Deval device for quality acceptance of aggregates. This test would eliminate the LA Abrasion and freeze and thaw soundness test we are currently using at least for sources that historically have very good aggregate quality. The freezer used for the freeze and thaw test has high maintenance costs.

3. Require Producers to pay for our expenses for out-of-State inspection. We have not had a significant problem in this area; however, with the large increase in our Construction program, we are getting interest from many out-of-State Producers that are beyond our designated distance to travel for inspection.

Missouri DOT

Missouri DOT will institute ASR per IDOT recommendations for precast products. They will most likely publish a rebar guide similar to the one handed out by IDOT. They are beginning to review consultant needs and found conversation of other states valuable. Found Texas design-build, especially with warranties, a potential strategy as MoDOT currently uses Practical Design. MoDOT will review TX aggregate acceptance program for quality of materials.

Texas DOT

Texas was unavailable for complete participation in the Peer Exchange based on ongoing project lettings and unforeseen conflicts. The primary participation by Texas was in their discussion (via webinar) of how they did, do, and will do business in the future specific to assurance of materials manufactured and supplied. They discussed the opportunities and challenges they face while using design-build strategies in Texas.

APPENDIX 11.

NCHRP 10-83 [Request For Proposals]: Alternative Quality Management Systems for Highway Construction

Posted Date: 10/19/2009

Project Data	
Funds:	$500,000
Contract Time:	27 Months
(includes 1 month for NCHRP review and approval of interim report and 3 months for NCHRP review and for contractor revision of the final report)	
Authorization to Begin Work:	5/1/2010 -- estimated
Staff Responsibility:	David A. Reynaud Phone: 202-334-1695 Email: dreynaud@nas.edu
RFP Close Date:	12/9/2009
Fiscal Year:	2010

BACKGROUND

Project delivery methods in the construction industry have evolved and so have quality management systems. Changes in the roles of owners and contractors in delivery systems range from the highway standard design-bid-build system to design-build/public-private partnership agreements where the responsibility for quality management is shared to varying degrees between the contractor and owner. The design-bid-build system uses the traditional highway quality management system (referred to in this project as the baseline quality management system) with detailed contractor quality control requirements strictly monitored by the owner. The attraction of alternative project delivery methods is the transfer from owner to contractor of some measure of project responsibility that may include design, finance, and/or quality management. These alternatives may result in substantial savings to the owner from lack of design error and omission claims, lower cost of capital, and reduced employment of project management and inspection forces. These alternative project delivery methods have proven to be efficient and effective in many types of construction and are increasingly making inroads into the highway construction arena.

One aspect of alternative project delivery methods that may be applied to highway construction now is the application of alternative quality control systems that emphasize contractor quality control and assurance. These new systems allow owners to have confidence through a verification of contractor quality system process. As an example, a formal quality management system, under the International Organization for Standardization (ISO)--ISO 9001 Quality Management Systems--Requirements integrates quality management from the suppliers through the contractors to the owners. It requires post-project reviews and publishes ratings of contractor performance. During the project, the owner verifies that the contractor's quality management plan is in force, rather than providing extensive, detailed specifications and conducting the on-site tests required by the baseline quality management system. Another

alternative method is the U. S. Army Corps of Engineers' quality management system. This system provides extensive, detailed specifications and permits on-site testing by contractors.

Research is needed to provide guidance on the use of alternative quality management systems for highway construction projects.

OBJECTIVES

The objectives of this research are to (1) identify and understand alternative quality management systems and (2) develop guidelines for their use in highway construction projects.

Accomplishment of the project objectives will require at least the following tasks:

TASKS

Task descriptions are intended to provide a framework for conducting the research. The NCHRP is seeking the insights of proposers on how best to achieve the research objectives. Proposers are expected to describe research plans that can realistically be accomplished within the constraints of available funds and contract time. Proposals must present the proposers' current thinking in sufficient detail to demonstrate their understanding of the issues and the soundness of their approach to meeting the research objective.

Phase I

Task 1. Based on a domestic and international literature review and a survey of appropriate agencies/organizations, identify and describe quality management systems that are used in the construction industry, with emphasis on those that can be applied to highway construction. This should include an examination of ISO 9001 and the U.S. Army Corps of Engineers approaches, as well as other systems that merit investigation.

Task 2. Describe the integration of quality management systems identified in Task 1 with various project delivery strategies, such as: design-bid-build, best value, design-build, public-private partnerships, and others.

Task 3. Gather additional information from stakeholders either through interviews, case studies, or other means to allow for a comprehensive evaluation of alternative quality management systems.

Note: Proposals should provide details on how this additional information will be collected.

Task 4. Identify and discuss the advantages and disadvantages to the contractor and the owner of each of the alternative quality management systems. Consider contractor factors such as consistency, productivity, costs, risk management, employee awareness, on-time delivery, staffing levels, timely completion of testing, product performance, risk alignment, strengthened business capabilities, more consistent management structure across jurisdictional lines, and reduced claims. Consider owner factors such as product performance, inspection costs, staff allocations, overlapping work activities, use of contractor incentives and disincentives, and risk assignment.

Task 5. Contrast each of the alternative quality management systems with the baseline quality management approach.

Task 6. Prepare an interim report on the results in Tasks 1 through 5. The interim report shall also contain an updated work plan for Phase II. The research plan shall provide a 1-month period for review and approval of the interim report. An interim meeting of the project panel to discuss the report with the research agency will be required. The research agency shall not begin work on the remaining tasks without NCHRP approval.

Note: Although a detailed work plan for Phase II will be developed as part of Task 6, each proposal shall contain the research agency's current thinking on how Phase II should be undertaken.

Phase II

Task 7. Based on panel direction, develop guidelines to match selected quality management systems to the appropriate types of construction projects and alternative project delivery methodologies. For each recommended quality management system and the appropriate project delivery method, describe the potential implications to owner organizations and the highway construction industry if owners were to adopt it as a standard practice. Identify the barriers to implementation and ways, if appropriate, to overcome them.

Task 8. Identify how the baseline quality management system could be incrementally improved by potentially incorporating portions of alternative quality management systems. Identify adjustments to each alternative quality management system that could be implemented to accommodate traditional low-bid contracting and public-private partnership projects.

Task 9. Prepare a final report that documents the research and includes the guidelines for applying alternative quality management systems to various highway project delivery systems.

APPENDIX 12.

BMPR accomplishments after the QA Peer Exchange

Metals and Miscellaneous:

Reinforcement Bars: With the upcoming retirement of the chair of the NTPEP reinforcing steel program, IDOT's Metals & Miscellaneous Unit head was accepted as the new vice-chair of the steel committee. Beginning January 1, 2011 IDOT will require that all certified steel mills be NTPEP compliant in order to retain their certified status. Additionally, IDOT will be performing third party testing for the NTPEP reinforcing steel program.

Welded Wire Fabric (WWF): A work plan for WWF is currently being developed through NTPEP. Once completed IDOT plans to play a similar role as the reinforcement bars and would also like to be the chair or vice-chair of the committee.

High Density Polyethylene Pipe (HDPE): In addition to IDOT's current specification requiring that pipe be tested each construction, IDOT has required that all manufactures of HDPE become NTPEP compliant beginning January 1, 2011.

Fabric: IDOT has been working with industry to have the manufacturer, product name and specification stitched into the material at a regular interval. We are also looking at the NTPEP program as a source for acceptance for all fabric material.

All of the above changes require that the Manual for Materials Inspection and Project Procedures Guide be updated to reflect any changes to the method of acceptance and evidence of inspection. Several new materials were added to these manuals as well as numerous materials were removed due to lack of use. The acceptance method for testing some "low risk" materials has been changed from test to manufacturer's certification. For materials with a low failure or low risk of failure the testing frequencies have been reduced.

Aggregate

Equipment: Purchased 10 Micro-deval machines to increase productivity of the lab. Productivity was increased by using the devices to quickly test all previously approved incoming aggregates and eliminating 40% for further, labor intensive tests. Micro-Deval is also being used to determine the quality of aggregate in RAP.

Manpower: Use a consultant for all specific gravity testing. This contract has been extended. Hired a new technician and two, potentially four, additional temporary staff.

Concrete

Eliminated testing of most concrete admixtures and changed acceptance to manufacture's and third party certification.

Chemical Tests

PG Asphalt Binder Sampling at HMA Plants: Increased the sampling frequency from once a month to once a week during mix production. Began requiring the samples to be taken from the HMA plant injection line (asphalt line just before entering the mix). Recognized that the spring (April, May, and June) failure rate is more than twice that of any other time during the construction season. (Ref. PG Asphalt Binder Sampling at HMA Plants Summary, 2010, below).

Structural Steel Coatings: Illinois' material specification for "Organic Zinc-Rich Paint System" requires NTPEP testing for prequalification. Continued testing each batch of paint for final acceptance.

Sign Sheeting: Reviewing NTPEP program to use for prequalifying materials.

Pavement Marking Materials: Reviewing NTPEP program to use for prequalifying materials.

Manpower: Used a consultant for collecting asphalt samples from suppliers for 2009. Hired two chemists in early 2010 and currently have three temporary staff.

		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total Samples	Total Failures
D #1	Samples	0	0	0	17	81	141	49	105	103	89	67	2	**654**	
	Failures				2	3	2			3	1	1			**12**
D #2	Samples	0	0	0	6	16	25	27	51	40	41	9	0	**215**	
	Failures				1		1		1		1				**4**
D #3	Samples	0	0	1	6	11	6	23	25	28	20	1	0	**121**	
	Failures				1										**1**
D #4	Samples	0	0	4	9	27	20	42	47	34	31	6	3	**223**	
	Failures														**0**
D #5	Samples	0	0	0	11	19	26	24	33	23	27	11	2	**176**	
	Failures														**0**
D #6	Samples	0	0	0	8	19	20	30	48	39	47	16	0	**227**	
	Failures						1			1					**2**
D #7	Samples	0	0	0	17	38	34	32	21	29	21	17	0	**209**	
	Failures						1								**1**
D #8	Samples	0	1	4	30	32	20	34	35	31	37	17	8	**249**	
	Failures			1			3		3						**7**
D #9	Samples	0	0	0	7	22	11	21	17	15	21	4	4	**122**	
	Failures										1	1			**2**
Total	**Samples**	**0**	**1**	**9**	**111**	**265**	**303**	**282**	**382**	**342**	**334**	**148**	**19**	2196	
Total	**Failures**	**0**	**0**	**1**	**4**	**3**	**8**	**0**	**4**	**4**	**3**	**2**	**0**		**29**
% of failures by month					3.6	1.1	2.6	0.0	1.0	1.2	0.9	1.4	0.0		

PG Asphalt Binder Sampling at HMA Plants Summary, 2010 (V. Prill)

Hot Mix Asphalt

Purchased and put into operation (2) Hamburg Wheel Tester units (HWT) at BMPR and District One. Additional units will be purchased as soon as the budget allows. IDOT is continuing to move toward additional 'torture' testing of HMA to ensure the best product possible is bought and built for the motoring public. The QA Peer Exchange consensus was that the HWT was the state of the art and most economical way of getting there quickly.